YEAR BOOK

OF THE

American Iron and Steel Institute

1924

MAY MEETING - - - - - - NEW YORK
OCTOBER MEETING - - - - NEW YORK

Published by the
AMERICAN IRON AND STEEL INSTITUTE
40 Rector Street, New York

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PRINTED IN THE U. S. A. BY
WYNKOOP HALLENBECK CRAWFORD COMPANY
NEW YORK, N. Y

PREFACE

This book constitutes the fourteenth volume of the series containing the proceedings of the General Meetings of the American Iron and Steel Institute. The first volume, containing the proceedings of the First General Meeting, held in New York on Friday, October 14, 1910, and continued in Buffalo, Chicago, Pittsburgh and Washington, was published under the title "Proceedings of the American Iron and Steel Institute." In 1911, no General Meetings were held. In 1912 and subsequently two General Meetings have been held each year with the single exception of the year 1918, the October Meeting of that year being omitted because of war activities. In 1912 the proceedings were first published under the title "Year Book of the American Iron and Steel Institute," and this title has been continued in subsequent volumes.

The present volume contains the proceedings of the Twenty-fifth General Meeting held at the Hotel Commodore, New York, May 23, 1924, and the proceedings of the Twenty-sixth General Meeting, held at the Hotel Commodore, New York, October 24, 1924.

HOWARD H. COOK,
Assistant Secretary.

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AMERICAN IRON AND STEEL INSTITUTE

TWENTY-FIFTH GENERAL MEETING

NEW YORK, MAY 23, 1924

The Twenty-fifth General Meeting of the American Iron and Steel Institute was held at the Hotel Commodore, New York City, on Friday, May 23, 1924.

Following the usual custom, three sessions were held. In order to provide sufficient accommodations for the large number present, the morning session was held in the Grand Ballroom. The afternoon session was held in the East Ballroom. The evening session, which included the semi-annual dinner, was held in the Grand Ballroom. The sessions were devoted to the reading and discussion of papers dealing chiefly with problems of metallurgy and business.

On the following page will be found the program of the meeting. Judge Gary, President of the Institute, presided at the opening of the morning session. At the close of his address, Judge Gary requested Mr. John A. Topping, Vice-President of the Institute, to take the chair. At the request of the President, Mr. William A. Rogers, a director of the Institute, presided during the afternoon session. Judge Gary acted as toastmaster at the banquet in the evening.

PROGRAM—MAY MEETING

MORNING SESSION

Address of the President.....ELBERT H. GARY
Chairman, United States Steel Corporation, New York.

Uniform Coking Coal as a Factor in Blast Furnace Economy.....WALTHER MATHESIUS
Superintendent of Blast Furnaces, Illinois Steel Company, South Chicago, Ill.

Discussion.....JAMES B. PAULEY
Vice-President, J. K. Dering Coal Company, Chicago, Ill.

Discussion.....HENRY R. DEHOLL
Superintendent of Coke Ovens, Inland Steel Company, Indiana Harbor, Ind.

Selling Practices in the Steel Industry.....ERNEST T. WEIR
President, Weirton Steel Company, Weirton, W. Va.

AFTERNOON SESSION

The Manufacture of Steel for Ordnance Purposes.....COMMANDER J. B. RHODES, U. S. N.
United States Navy Yard, Washington, D. C.

Discussion.....R. F. FLINTERMANN
President, Michigan Steel Casting Company, Detroit, Mich.

Discussion.....JOHN A. MATHEWS
Vice-President, Crucible Steel Company of America, New York.

Discussion.....F. E. CLARK
Electric Furnace Engineer, Milwaukee, Wis.

Composition of Raw Materials and Pig Iron Costs.....THOMAS T. READ
Acting Assistant to the Director, United States Bureau of Mines, Washington, D. C.

Hardened and Ground Rolls.....J. R. ADAMS
Superintendent, Research Department, The Midvale Company, Nicetown, Philadelphia, Pa.

Discussion.....F. C. ELDER
Metallurgist, American Steel & Wire Company, Pittsburgh, Pa.

The Cleaning of Blast Furnace Gas.....G. M. HOHL
Superintendent of Blast Furnaces, Bethlehem Steel Company, Bethlehem, Pa.

Discussion.....J. C. BARRETT
Blast Furnace Superintendent, Ohio Works, Carnegie Steel Company, Youngstown, Ohio.

Discussion.....N. H. GELLERT
President, Gellert Engineering Company, Philadelphia, Pa.

Power Consumed in Rolling Steel.....GORDON FOX
Electrical Engineer, Freyn, Brassert & Company, Chicago, Ill.

Discussion.....J. D. WRIGHT
General Electric Company, Schenectady, N. Y.

Discussion.....E. FRIEDLAENDER
Superintendent, Electrical Department, Carnegie Steel Company, Braddock, Pa.

EVENING SESSION

Impromptu Remarks in Response to Call of the President.

ADDRESS OF THE PRESIDENT

ELBERT H. GARY

Chairman, United States Steel Corporation, New York

The discipline of this organization is as good as the military. It is very seldom you will see so large an audience immediately come to a condition of perfect order upon hearing the sound of the gavel; and again I congratulate you on your disposition.

It is a great pleasure to greet you on these occasions, not alone because of your cordial reception, which is always fine and friendly, as it is very much appreciated, but because of the great interest you take in this Institute and the good work you are doing.

I fear you will be somewhat disappointed by what will be said this morning because the remarks of the President during the morning session will be entirely impromptu. I prepared something to read relating to your war work because I thought it was not only proper but in fact from my standpoint a duty to see that a permanent record should be made which, though short, might be comprehensive and strictly accurate, placing the steel industry of this country in such position that whatever should be said by anyone, if contradictory to the facts, might be corrected by our records; but after its preparation, without having seen it or known anything about it, Mr. Farrell, the Chairman of the Committee on Arrangements, and the one whose arbitrary decisions concerning the program have never been appealed from, decided that what I had prepared for the morning should be reserved for this evening. Therefore, if what I say without prepa-

ration or reducing it to writing, is somewhat crude and possibly somewhat tedious, you will overlook it.

I am going to say something about my trip to South America. Some of you will be interested; perhaps all of you. The address on South America should have been made by Mr. Bowron, President, Gulf States Steel Company, who made the trip, went farther and stayed longer than I did. He keeps a diary faithfully, and he has done so for sixty years I think. He has a good voice, as you know, and he is strong and vigorous; but what he learned will not be lost, for he will write a book on the subject I am pretty certain. When it comes to speaking Mr. Bowron has only one fault, and perhaps that is a virtue. He has so much in his head and so much in his voice and so much in his memory that when he gets started on an important subject sometimes his wife is compelled to tell him he talks too long (laughter). He knows me so well he will permit me to make that suggestion, not for now, but for some time later perhaps when, after we have heard him the allotted time, I am compelled to strike the gavel. I may refer to Mr. Bowron a little later in the course of my remarks.

Before I commence to talk to you I wish to have you endorse and approve a resolution which was lately passed by the Board of Directors, because I think it should be written up as a part of the record of the proceedings of the Institute:

> "Resolved by the Board of Directors of the American Iron and Steel Institute, That to the extent the United States Government may need the assistance of the iron and steel industry in the maintenance of conditions adequate for the military defense of this country, we pledge the active efforts of the members of this Board, and we express the belief that the entire iron and steel industry will approve the sentiment expressed and will cooperate in carrying it into practical effect."

Will you endorse and approve that? If so, those in favor say aye; contrary, if any, no. It is unanimous.

On the 7th day of February which, in my judgment, is a most appropriate date considering weather conditions, I started for South America from New York on the *Santa Teresa* of the Grace Line. The ship was fine, the captain a high type, fully competent, most agreeable, the other officers and the crew likewise, the service was first-class, and the cook was excellent (laughter). That is one of the things that Mrs. Gary always makes careful inquiry about before we start. Many of us are inclined to overlook that feature, and it is a sad mistake.

We sailed directly south toward Panama. It was a little cold when we started, but two days later the weather was warm and exactly right. Nothing of great importance occurred except we began to get well acquainted with the passenger list, which was most agreeable, until we reached Panama.

Those of you who have never seen Panama, the great canal, the City of Panama on the Pacific coast with its adjacent city of Balboa, and on the Atlantic coast, Colon, the principal city, will find them fine, progressive, and healthful. The whole situation from one end of the canal to the other is a surprise to the stranger who first visits the location. The stupendous undertaking and magnificent results in building the canal you know all about; but you cannot thoroughly visualize all that was done there and especially what was accomplished by Major General Gorgas in cleaning up a location that theretofore was unhealthful and deadly. He built for himself a perpetual monument to the greatness, intelligence and energy of a very learned and accomplished man, in time of stress. The hotels there are excellent. The scenery is good. Altogether you will be delighted in seeing that great enterprise and what has been done.

After passing through the canal, the ship sailed on towards the south. We saw comparatively little of great interest on the way down to the South American coast except a few whales, a good many sea lions and a con-

siderable number of birds and various smaller fishes and some beautiful islands, until we reached the equator.

There are some things noticeable about the equator when you first make the visit. In the first place, so far as my experience goes, on the eastern and on the western coasts of South America, the hottest place is not directly at the equator. We did not find any warmer weather nor as warm weather as we found somewhat distant from the equator. I think generally it is not any hotter, if as hot, as at other somewhat distant places. But as you approach the equator, the headquarters of Father Neptune, who rules the sea, there is prepared an entertainment which consists of an initiation to the person who first crosses the equator, which is, to say the least, unique and very interesting.

The passengers are notified, indeed they are summoned, to appear before his majesty, the king, the ruler, the great Neptune, for examination in regard to their conduct, their standing, their reputation and their inclination. No one is exempt. Father Neptune, with his long white whiskers, his attendants and associates and inferior officers, is located on one of the forward decks near the swimming tank, and sits there in judgment. Father Neptune is a stern and arbitrary individual. There is no appeal from his judgments, and the man who is not qualified and safe in appearance at that court had better not take the voyage.

Well, I got along first rate. Mrs. Gary was with me. Having heard something about it, she declined to appear, but I said to her, "There is no escape. When a summons comes from a court we must go and take our medicine, whatever it is, and by so doing we throw ourselves upon the mercy of the court and will stand a better chance of escaping severe punishment." And it so proved. But one after another of the indicted or accused came in. Some of them must have been notified that they had better be prepared for emergencies, and they were dressed accordingly. Judgment was pronounced against those

who appeared, and in one case the culprit would be pelted with eggs, and in other cases would receive different punishment. Generally the men were requested to sit down in a certain chair; immediately the barber with lather in one hand made up of the white of egg and other things, asked him a question; when he opened his mouth to answer, it was filled with this lather; then he was besmirched with what the man held in his hand; then with razor blade about that long (indicating) he was shaved and his head was tossed this way and that way and the other, and finally, rough treatment was inflicted. If the individual objected his legs were immediately seized by one man and his shoulders by another and he was pitched into the tank heels over head, clothes and all, and he got out the best way he could. And the ladies were treated similarly, except for obvious reasons they were not shaved.

Some days after passing the equator, Mr. Bowron and his wife came on our ship, having left the ship they sailed on, for a trip into the interior of Bolivia, going to the location of the highest city in the world, I suppose, some 12,000 feet above the level of the sea. And they submitted to innumerable hardships which I think they took with previous knowledge, because Mr. Bowron wanted to show them he could do what anyone else could do. Some day he will have a chance to dispute this, but no doubt they saw many things that were very, very pleasant.

Remembering what had occurred that day, having vividly before me the appearance of Neptune, the judge, obdurate, and as some of them thought, unconscionable, I said to Mr. Bowron, "Were you present at the festivities when you crossed the equator?" "Certainly I was." "Well, how did you get along with Father Neptune, how did you feel when they put you in the tank?" He stood up before me on the deck of the ship—there he sits now (pointing),—with his long white whiskers in front of him, standing as straight as an arrow. He said, "I was Father

Neptune (laughter and applause), duly and appropriately selected, decorated and voted thanks for my splendid behavior as judge, merciful and yet reasonably stern."

There are two things that are noticeable to a stranger at the equator. In the first place, I have mentioned the climatic condition. The other is that at noon the sun is right over you, exactly over you, at the season I was there at least. And, as you begin to sail on south of the equator, you begin to see the sun passing north of you instead of south and consequently you see the shadows on the south of the object which makes the shadow, instead of on the north. It is a little difficult to get accustomed to the long shadows going south, but of course that is perfectly natural and you can understand it.

We sailed on easterly and southerly until we struck the coast of South America, stopping for a few hours only at one of the oil fields owned by the Standard Oil, which we visited and found very interesting indeed. And then we came to Lima, or Callao, the port some little distance from Lima, at which the passengers alight, going there by automobile or any other conveyance. Lima is a fine old city. I enjoyed it immensely. The climate was good, it was warm but not oppressive. The cool Humboldt current, extending along and near the Western Coast of South America for several thousand miles, insures a desirable and refreshing temperature. The old university is there, the old cathedral, and the fine palace that you read about in which the foreign minister, Mr. Salomon, gave a very fine luncheon, attended by the functionaries and many prominent citizens of the city, men and women. The streets are good and well paved. The hotels are reported to be rather poor. Therefore our local people rented for us, out on the sea shore, five or six miles distant, a new house, newly furnished, and we were very well accommodated there, for we supplied our own food. All in all, our visit there was most agreeable, and it is a

city which under no circumstances should you omit or pass by. The President speaks good English, is highly educated and a fine, splendid man, though arbitrary in his disposition and ruling, as he has to be in that country in order to maintain perfect peace and tranquillity. Of all the presidents of the various republics which I visited, he is the only one who speaks English. The others talk to a stranger through an interpreter.

We sailed on down the western coast for many days. The ship stopped at various villages or little cities. We were close to shore. The ship anchored outside some little distance and the passengers were transferred when it was possible, by one kind of a sea craft or another, all of them small enough and poor enough and unsteady enough. If it was possible to step from the ship to the conveying transport, and from that to the shore, it was done in the usual way; otherwise baskets and lifting cranes were used. But I tell you once for all, with reference to all of the places you stop, where there is no dock which can be approached by the ship, you had better not go ashore if you think you can see the town very well from the ship, which is generally the case. I had had some experience the year before in my Mediterranean trip. Imagining this is the deck of the ship (indicating) and the transport is on the sea, the waves carry the transport up and the ship down, perhaps at the same time and perhaps not at the same time; and you must wait your chance when the two are about level, and as the foreigner said, "yump," and if you cannot make it in one "yump" then "yump" twice; and it is mighty disagreeable. Avoid the private launches. We tried just one of them afterwards, about the only time we went ashore under such circumstances as that, and Mrs. Gary and I both thought that that ride would be the last one ever taken by anybody in that launch, because it did seem as though she would tip over and sink.

We passed by scenery, which, to my mind, was very interesting, although you will hear it spoken of as bar-

ren, bleak, and unsightly. There are no rains to speak of until you get to about the middle of Chile. It is a very dry country. There are no trees, but the contour of the mountains and the beautiful and great variety of colors are magnificent to behold if one is observing and pays careful attention to what may be seen. I would not have missed seeing that shore for thousands of miles for anything.

We went past the big mine of the Bethlehem Company but did not stop, for lack of time. They have a great mine in Chile, not so very far from Valparaiso. They have a mountain of ore. Instead of mining from the top, they mine from the bottom. In order to get a short distance to the top they go around and around the mountain, in climbing, and I think it takes about twenty-six miles to go a distance of two or three or four. They did not go there for convenience nor even for beauty or for landscape; they went there because they have iron ore that in iron content is about 70 per cent. Now, I am not going to say too much about that, because I do not want to discredit by comparison the ore we have, but it is a good thing they have it. There is a great abundance of it, not only on the western coast but in other places. And I may speak of that subject later, although I fear, as I am going, it may take too much time.

The approach to Valparaiso is very handsome. There is a fine protected bay. It is a great relief to get there. It is pleasant to come into the view of a beautiful city after having passed by many small cities, almost small enough to be called villages, witnessing the devastation of earthquakes in one place or another. And on your whole journey you rarely come close to land without seeing the top of a mountain cut off and scooped out, resembling some of the volcanoes which you have seen in Italy and other countries.

For twenty-four hours or more before reaching Valparaiso the traveler passes immense numbers of sea fowls, ducks, geese, pelicans, guan birds, etc., in great va-

rieties, aggregating hundreds of thousands, perhaps millions. It is a wonderful sight, one never to be forgotten.

Valparaiso, while it has been injured by earthquakes which were serious, yet has escaped total obliteration, as some other cities were subjected to. The harbor is fine. There you go up to the dock and you see this splendid city located, so far as the business part of it is concerned, in a narrow level strip by the sea, but as to the residences, to a large extent, sloping up the mountain; and it is a beautiful sight to see. The hotels there are good. The new buildings are fine. The people are progressive. The food is excellent. The race track is one of the best and the jockey club is splendid. The banks are progressive and rich and prosperous. The best club is out on the sea and large numbers of members take great delight in extending hospitality to the stranger. And if you go there and are a little acquainted you will be received and entertained there magnificently,—cool air on the sea, best of food, the best of everything and the most hospitable disposition.

From Valparaiso you go towards the mountains. All along the coast there is the coast range of mountains and then over that range is land which is nearly level and fertile and cultivable, and then you come to the Andes, the great mountains of South America, another range running parallel with the sea. But before you get to the Andes, by changing cars, or at least by changing railroads, you will reach Santiago, some sixty miles distant from Valparaiso, a most beautiful city. I think Valparaiso has perhaps 275,000 to 350,000 people and growing fast. Santiago has some 500,000 or 600,000, perhaps 650,000 people, progressive, beautiful, strong, rich, with surroundings that are very agreeable, a climate that is good and healthful, a stock exchange that is large and active and not very much unlike the stock exchanges with which you are familiar in this country, except the foreign exchanges entertain strangers, and, if they are allowed to search him first, they will permit him to come

on the floor of the stock exchange with the members. Their manner of doing business there and in other South American stock exchanges—and I mention this only as typical—is different from ours. An auctioneer stands in front of the desk on a dais or raised platform and auctions off the commodity or the security in question. bids are made for it and in that way they establish a market price. After that is done the dealings are conducted privately. Following the session of about an hour or an hour and a half they will invite you to a repast where they will furnish anything you want. For a person like me there is not so much to partake of except sandwiches and cake; but for some of you they would also have a little champagne. They leave it to you. Their hospitality is unbounded.

Then the banks will get together and in one of the biggest bank buildings you will go through substantially the same performance as at the stock exchange, so far as being received, introduced, fed, and wined if you like it; and in other ways the hand of friendship is extended to you and evidence is given that they are no better and no worse than the ordinary individual in New York or any other American city where they are inclined to deal in securities and to deal in friendly intercourse and conversation in connection with their business.

All in all, Santiago is a very attractive place with its surroundings, its mountains in sight at a distance, its great race track, one of the best you will see anywhere in the world, its two mountains within the city limits, on the top of which there are opportunities for entertaining the stranger, where the governor of the state receives, and the best people are generally inclined to visit. The scenery is magnificent, the food is good, the accommodations of all kinds are excellent, and when you drive around the city you will see very much that will interest and surprise you because of the progress and growth they are making.

And then our Ambassador, Mr. Collier, will meet an

American at the station, greet him as a long lost friend and do what he can for him. He will take one anywhere and everywhere of importance. He has a mansion, which our Government bought because it was cheap and is good enough for any ambassador anywhere in any country. He will introduce you, if you have time, to the President, who does not speak English but who talks through an interpreter and will immediately convince you that he is very much interested in the United States of North America and would like to have you interested in him and his country. He is intelligent, fair minded, very receptive and notwithstanding the publication of erroneous reports in the papers of this country to the effect that there were disasters and riots in Chile at that time, there was an important election when I was there and so far as I could see or hear or read there was perfect peace and quiet and order.

The newspapers there are fine. One of them is as good as you will see anywhere, filled with news, generally in Spanish. In South America wherever you are you had better make certain to have a good interpreter who speaks Spanish or French, or, if in Brazil, Portuguese so that you can converse with anybody.

From Santiago we went on a special train provided, to an immense ranch,—whatever the name may be in French or Spanish, I suppose *estencia,*—up a valley for thirty or forty miles, where we found a gentleman with an immense tract of land and a lake with several islands in it, that was formed by diverting a stream when they built a railroad. There we received the most hospitable treatment and met some of the finest men and women you can see anywhere. All in all, the disposition is to be hospitable.

From Santiago we went to Los Andes. I have forgotten the distance now. Mr. Bowron will tell you.

Mr. Bowron: About sixty miles.

Judge Gary: About sixty miles, a ride of about two and a half hours, as I remember. The hotel accommoda-

tions there, while old and well known, are too old and not well enough known to be very comfortable. I had a little advantage of Mr. Bowron there, I expect. I do not think there is a very good place to sleep unless you happen to have your own car. If you do, you can sleep in that and be comfortable. More than that I could not promise. But it is all worth while, because the scenery is fine and the temperature is excellent and the climate above reproach.

From there you go up the mountains. The train starts early in the morning and it takes all day to get over the mountains. You change railroads twice. Once you change to get onto what I call a cog railroad, because in going over the peak or divide the grade is so steep that an ordinary train cannot travel and you have to go on this cable or cog railroad for safety.

The scenery going up the mountain is grand. No fault could be found with it when compared with Switzerland or any other country. It is well worth while going to see.

At the top you are about 10,500 feet above the sea level, but you go through a tunnel which cuts through the mountain and you have to change railroads again there because the peak is the dividing line betwen two great republics, Chile and Argentina, heretofore deadly enemies, both equipped to fight and having the disposition to fight. The Chileans are noted for their bravery and their success. They have been so successful in war that other nations more or less beware of them. Man for man they are probably the best in South America, although that would not be admitted perhaps by other republics; but as good as you will find in any country. Argentina and Chile were at sword's points for a long time, until finally they settled their differences, came to a happy solution and signed a permanent covenant for peace. On the top of the mountain where you cannot see it from the train, but will have to change and by some conveyance get to the top in order to see it, there has been established a magnificent monument to the covenant of perpetual peace be-

tween those two countries. Since it was made, there has never been any substantial violation and it is to be hoped there never will be. If those two countries stand together, they are pretty safe from contest with other countries and especially safe as between themselves.

In considering that monument I could but wish that some time, somehow, some place, there may be established a covenant and a monument which shall forever and ever be an assurance of the carrying into practical effect and maintenance of such a covenant, thereby securing a condition of peace and tranquillity between all the nations of the earth. (Applause.) This may happen, and it may happen sooner than we expect. Necessity, or what is better, a conversion to the principles of truth and justice and Christianity may demand and require that all the nations shall get into this frame of mind. And the United States, big and strong as it is, rich as it has become, can afford to take the lead in every effort that shall bring about perpetual peace on earth and good will to men, so far as it is possible without doing injustice to itself. (Applause.) "God moves in a mysterious way His wonders to perform." Let us hope for the best.

Going down the other slope in Argentina the scenery, taken as a whole, in my judgment is not as good generally as it is when you are going up from the Chilean side, but nevertheless it is fine and grand. Especially I would call your attention to two things which very much interested me and attracted my great admiration. I refer to the two very high mountains which are distinctly seen when the atmosphere is clear, as it was when we crossed. On these two great mountains, whose names I do not now remember or at least I cannot exactly pronounce them just at this moment, 23,500 feet high, two miles higher than Pike's Peak or Long's Peak and other great mountains in this country which for ages have stood as monuments to the stupendous importance of our mountainous regions; on those two miles or more from the top of the mountains there is perpetual snow. I have not time to de-

scribe them, except to refer briefly to one of them which must have interested Mr. Bowron as much as myself. One looks up a valley, I believe thirty miles from the train, and you know in such a country as that, where the altitude is high, distances are very much greater than they seem to one not accustomed to them. It only appears to be a short distance from the train at the lower end of the valley, though that is not really the end, and one sees one of these mountains almost regular in shape. About all you see of it is a pyramid almost perfect in proportions and uniformity of line, a mountain of snow, a wonderful and never to be forgotten spectacle. Near the place where the train later passes, is a natural bridge, solid stone, crossing over the stream which appears to one who does not know anything about it to have cut through solid rock in the course of time, leaving this natural bridge. If so, it was once solid rock and the water some place or another leaking through, freezing and chipping off the stone, finally formed a perfect tunnel. That was a grand sight.

As you go down out of the mountains you strike another railroad and very soon enter upon the great pampas of Argentina. It is a wonderful sight. It is a long ride, very often dusty and disagreeable, but there was no substantial inconvenience when we crossed.

Passing over these immense plains was to my mind very agreeable. We saw great fields of wheat and corn and pastures and live stock, cattle by thousands upon thousands and sheep in large numbers and horses, some almost wild, cattle and buffalo originally from Africa, birds of great variety, all kinds of ducks and geese and cranes and kindred fowls coming up even to the ostrich running wild in very large numbers. That interested me. I had never seen it before.

But in passing over these plains I must make this observation. South America in many locations has her wealth, her mineral wealth particularly. But minerals disappear. You take a ton of iron ore out of the ground

or copper or gold or silver or lead or whatever it may be, and it is gone, except as you can save small portions of the scrap. But the agricultural mine never disappears, it grows, or if properly cared for, should grow better and better and it is perpetual. And that is one reason why the United States of North America is not only rich but it has a productive capacity that will never permit this country to get poor or to be unsuccessful or to stop progress or delay it for long unless by our own conduct and mismanagement we deserve to be punished by a wise Providence that always does exactly the right thing, and because immutable laws never permit wickedness to go too far without punishment.

Because of the advantages mentioned Argentina has become rich and has established on or near the East Coast, on the Plate River, which is really an inlet from the sea, but a very wide stream at its mouth, being 100 miles or more across from one shore to the other, the biggest city in South America, Buenos Aires; rich, cultivated, with fine buildings and boulevards and parks, good hotels, making great progress, having a population of about two millions of people, increasing rapidly, it is bound to become and remain one of the greatest cities in the world.

It is well worth visiting and the people of Argentina, although proud and in some respects a little distrustful of the people of the United States, as probably they have reason to be, are fine, neighborly, hospitable and well worth visiting.

While at Buenos Aires, I also visited by railroad and automobile an *estencia* in Argentina belonging to Mr. Samuel Hale Pearson, 26,000 acres, well stocked with the finest of horses, cattle and sheep. The day was most enjoyable.

I cannot stop to tell you of the banks and great newspapers and other important things in Buenos Aires. From there you go across the Plate River about 125 miles, the best way you can to Montevideo. Sometimes if your

ship does not go when it was expected and had agreed to sail, if you wish to keep an engagement in Montevideo you will have to find some other means of conveyance. Montevideo has one of the finest sites for a city that I have seen. They have a city of 350,000 or 400,000. Uruguay is, comparatively speaking, rich. Her currency is sound and sells up to par or even a little better than par. The people are progressive and neighborly. It is a small republic but strong and rugged and the people are improving their situation all the time. Just at the time I was there our own people were building a fine large steel bridge with long spans over a river which empties into the Plate, the wide stream which I have mentioned. It is fully five or six miles over rather a rough road from the center of the city to where it was being built, and of course I went there so I could tell my own people that I had really been doing something while I was away beside playing.

From Montevideo we took a ship to Rio Janeiro, stopping one day at Santos, which is the port of Sao Paulo, the center of the coffee country. Santos has a beautiful entrance, and is a nice progressive city.

From there we went on to Rio Janeiro, as I have stated. There is a scene which is beyond my power of description, as all these places are for that matter. But you have read a great deal of it. We sailed in between islands in a very large bay and saw one of the most beautiful harbor approaches that can be seen anywhere in the world. The city is situated partly on level ground like Valparaiso, and then up the side of the mountains which surround the bay. You will pass what is called the Sugar Loaf Mountain away out in the bay, a high, regularly shaped round cone which stands there as a sentinel and also as a warning and likewise an invitation—a warning to the enemy and a salutation and welcome to the stranger who is friendly. It is a wonderful city, all in all. The shore is beautiful, the bathing beach, which is fully occupied by thousands of people a part of

every day, is one of the best. The buildings, the streets, the boulevards, the parks and newspapers are all very fine. I stayed there twelve days. The last five days were the hottest of any place I saw during the whole trip, still not as hot as New York in hot weather.

From there I visited our Corporation's manganese mine, which I cannot say much about because of lack of time, and certainly I could not speak of it at any length without boasting, which I detest. But it is worth having. It is only 300 miles distant from Rio. There is plenty of manganese ore, and we are very glad to own it, although we paid a very large price for it about three years ago. The trip was a little hard. The railroad is very curly, but nevertheless I enjoyed the visit.

I do not know whether I said Rio Janeiro has about a million and a quarter people, but that is the fact.

I also visited Sao Paulo 300 miles southwesterly. The mine I spoke of is northwesterly of Rio. Sao Paulo is perhaps the most progressive and the most rapidly growing city of any I saw in all of South America. It is the very heart of the coffee industry. From there is shipped I suppose three-quarters of all the coffee that is used, shipped, and distributed throughout the world. The land is on a plateau 2,500 feet above the sea. One sees new structures growing up on all sides when looking from the top of a high building. You would be surprised at what they are doing now and have accomplished, widening their streets and boulevards, the number of new buildings, the fine buildings in the business parts and in the residence parts. We found about 650,000 people, when I was there. By this time there are probably about 675,000, for its growth is very rapid.

If you go there do not forget to visit what is called the "snake farm," about five or six miles out. Do you know all about that? I believe that institution has been established and supported in whole or in part by the Rockefellers. I may be mistaken. But it is a wonderful enterprise. There have been gathered hundreds of

rattlesnakes and large numbers of other poisonous snakes for the single purpose of extracting poison that is found in the mouths or throats of those snakes, and utilizing it as an antidote to snake bites all over the Republic of Brazil. It will be found in the houses of practically all the people. The snake is taken in hand by one of the doctors who holds it by the back of its neck, while the tail is held by an attendant so it cannot coil. They cannot strike unless they are coiled, and they cannot strike more than about one-half their length. Then as another attendant holds a cup, the poison is pushed out of the throat by squeezing the fingers together, and it comes out into the cup. These snakes have stone houses to live in, several occupy each house. To show how venomous they are, one of the attendants wearing protecting boots of leather will go in amongst them, inside of the encircling walls or fences; and as he takes the snake out of its habitation with a hook and places it down in front of him, perhaps more than one at a time, he will pass his foot rapidly over the head of the snake and the snake strikes at him, sometimes hitting his boot but not usually. It cannot bite through the leather. There is an exhibition of how venomous and dangerous it is if attacked. Other snakes there can fly, to some extent. Did you ever hear of such a thing? If not, read Josephus. Read of the contest between the Egyptians and Ethiopians at the time Moses was drafted by the king to lead the Egyptian army against the Ethiopian army after it had been successful, fighting and conquering the Egyptians and had proceeded toward the sea as far as Memphis. Those of you who have been to Memphis will understand how that great city was destroyed and how Moses finally drove back the Ethiopians by going around by land to get in the enemy's rear, right through a country which was infested with these snakes which theretofore had prevented the army from moving by land. Read Josephus. I am only trying to excite your interest. Read that book in connection with the Bible, because that is contempo-

raneous history practically. Josephus lived almost in the time of Christ. It corroborates the Bible in one way or the other, particularly by citing from great numbers of contemporaneous histories. You will be interested and surprised.

But just one thought suggested by those snakes. I could wish—I do wish that the poison could be extracted from American politics. (Applause.)

From Rio Janeiro we started north on the eastern coast and our first objective was Trinidad. Trinidad is an English island. The Island of Barbados, also English, is the next stop. In Trinidad the principal products are the cocoa bean and sugar. It is well worth visiting. The roads are good, the scenery is delightful and the climate is first rate and you should not omit to stop there if you have a chance. The same is true of Barbados except their products are largely sugar. In Barbados the population is largely negroes. In Brazil also there are a great many negroes. In Trinidad there are more Indians and Hindoos.

From those Islands we started homeward. We went near the West Indies. The captain was good enough to go very close to those islands and we saw many of them very plainly, including Martinique, where Josephine was born and raised and from where she went over to France and married the first Napoleon. There was the great eruption of gas and other things that wiped out the whole City of Martinique when Mont Pelee exploded. The whole populace with the exception of one man was destroyed. That was one of the most wicked cities on earth, I am told. And who can tell, who can say that Martinique was not destroyed in the same way and for the same reason as Sodom and Gomorrah and other wicked cities like Corinth, and others that might be mentioned, in times when wickedness was so great that the wrath of a just God was the only thing that could stop its spread? There you can see where the top of the mountain was blown off and how the city was destroyed.

Then we passed one island and another, not stopping at any of them but going very near to Nevis where Alexander Hamilton was born and raised until he was fifteen, that great statesman who came to this country, who did so much for the United States in writing the Constitution, who was one of the biggest and I think one of the best men we ever had in this country, who was sacrificed, who was murdered in the duel just across the river near Hoboken simply because he stood for what he believed was right and against wrong, regardless of the consequences which in those days seemed necessary if one man believed himself insulted and challenged another to fight it out. Hamilton knew that he had no chance in that duel, for he was not a marksman. And it is probable he never pointed his gun at Aaron Burr, but stood up there unafraid in obedience to an unfortunate custom which existed at that time.

And so we passed on from one island to another. Many places I saw where tops of mountains had been blown off. Those islands are the result, I believe generally, of volcanic eruptions. They are very interesting and you would like to know more about them if there were time. From there we came home to New York. We had a most agreeable company on board that ship, all kinds of amusements, a very large water tank in which every day might be seen young men and young women diving from two decks above and exhibiting very great ability and skill as swimmers. The ship, the *Voltaire* of the Lamport & Holt Line, is splendid in all respects. Its captain is one of the best.

Now, gentlemen, I have been a long time on my feet. I am sorry to have detained you so long. Would you like to hear me say a word about business conditions, or not? (Applause and cries of "Go on.")

Well, it is very kind of you, and I wish I had more to tell you than I can. I have prepared no statement upon this question. Since returning from South America I have given to the newspapers my idea of the situation.

There has been little change since my last remarks to them.

To tell you that business is entirely satisfactory would be offending my sense of truth and propriety. To say that we are not producing as much as we would like or more than three-fifths of what we were producing when we were at the height, is only stating what you know to be an obvious fact. I would not be exaggerating if I should say to you that conditions in Washington have not been satisfactory. I have on more than one occasion hinted at conditions there and have deplored some of the action which has been taken. I have nothing to say against individual Congressmen. I fear that some of them have not been inspired by motives which are conducive to the best interests of the people of this country.

I suspect politics has entered into the discussions to a degree that is unjustified from the standpoint of good reason or good morals. But those if any who have been guilty of any impropriety or of the exercise of their rights from bad or unworthy motives must take the responsibility. Some of them talk as though they would like to secure votes by leading a portion, perhaps a substantial portion, of the people of this country, who have less in resources than others, to believe that they have been unjustly treated, to believe that they have not received their due proportion of the results of commerce and industry, and that if the speaker should be elected or retained in his present position, he will bring about something that will secure to these people who are possessed of less resources a position where they will be on a par and equality with others who have by economy and industry and good management been able to save something for themselves. But he does not say in the same breath what should go with it, from the basis of good logic or common decency, that if property or money or proceeds of activity are taken from a man who has earned and saved a part of his earnings, I mean without justice and without reason, we shall soon get to a point where all the people, including

those who have little, will have less, because prosperity will cease to exist and we shall be driven or shall drift into a position of industrial decay.

They do not say that. They overlook, purposely or otherwise, the fact that the people of this country, taken as a whole, must stand or fall together; that if the country prospers, every one will have the opportunity to prosper; that if it does not prosper, no one will have any chance for success. Sooner or later people will find out by the stern facts that such is the case.

Now gentlemen, in connection with that idea may I call your attention to the fact that in our organization, in our Institute, are represented both sides, those who produce and sell and those who purchase and consume. This is a time when there is such agitation as will likely bring about a depression in business; and the purchasers are inclined to bring about a decrease in prices if possible. The purchaser has the right in every honest way to secure low prices if he can, as the producer has the right in every honest way and up to a reasonable and fair point to secure larger prices. But I want to say to the consumer and to the producer alike that if by selfishness either side assists in bringing about conditions which benefit one and prejudice the other, the final result will be disastrous to both. There can be no escape from this conclusion. And to you producers who are asked to sell for lower prices than you are justly entitled to, you have a perfect answer when you say to the consumer: "You are just as much interested in your business, in what you do with the steel which you purchase, in the maintenance of fair and reasonable prices as the other side, the man or the institution from which you purchase. They must both go together."

I do not object to fair prices, reduction of prices when they are too high; I do not object to any kind of Governmental control or supervision which prevents imposition, which prevents a condition calculated to secure a monopoly or to enable the producer to impose upon the con-

sumer. But when that is done it must be done by an impartial competent authority, unprejudiced, unselfish and representing the Government itself. I do not object to the consumer arguing to the best of his ability for lower prices if he thinks it is for his interest and the interest of the country to have them lowered, and he thinks they are unreasonably high, when the high costs of production are taken into account; but I beg of him to remember, as I do both sides to remember, that there are others who are involved in the consideration of this question.

First of all, the wage earner himself. Just now there is some talk of reducing wage rates. Some reductions have already been made. The air is filled with suggestions that others should be made. I have nothing to say to another man in regard to his actions. He knows his own business and own ability to pay better than I do. But I do say this, let all of us remember that the costs of living are high.

In that respect the public not engaged in certain lines has been imposed upon by the cupidity and the greed of some who on account of particular circumstances have an opportunity to oppress. Some rates are entirely out of line and fully unjustified. The costs of living are high, and so far as we can, let us keep the wages high enough to give the man a good and reasonable support. (Applause.)

I am glad you loudly and vociferously applaud that sentiment. I know you believe it. Let us so far as the steel industry is concerned always do the right thing. Let us be just to everyone, even though we are not treated fairly from Governmental authorities, from Congressional representatives or even from some parts of labor. Let us maintain a record and a reputation for intending to do the fair thing, because thereby in the long run we do the very best thing for ourselves.

Now this country is not going into the hands of a receiver. There is a bright future for us. We are too rich,

too strong, the necessary demand for our products is too great to permit the country for long to go without buying liberally of what we produce. We will get our fair share of business. Let us do what we can to continue prosperity. Let us do what we can to hold up the hand of that great and good man who at the present time honors us by being President of the United States. (Prolonged applause.)

The long continued applause indicates how you feel towards President Coolidge, not because he is a Republican, not because a Republican is any better than a Democrat, for after all it is a question of what the man is, not what party he belongs to; but because he stands on the moral principles which alone make a country strong and vigorous and worthy of the high opinions of the people of this country and of all other countries. What a remarkable thing it is that during the last few weeks whenever there has been a primary election, even in the states of some candidates who have heretofore been supposed to be remarkably and uninterruptedly popular and successful, the name of President Coolidge going before the people has secured the almost unanimous approval of those who voted. That means more than party, that means more than the occupancy of a high position by a candidate at the present time. It means that at this time in the history of the world, in the history of this country, we happen to have a man who never regards himself or his own interests when deciding or acting upon any material question that is presented. He looks to the best interests of his country. He would sacrifice himself and his chances if by so doing he believed he benefited the people as a whole. It is because he stands for moral principles, for honesty and integrity and frankness; and entertaining those sentiments, naturally he can afford to be courageous and outspoken and bold and he will be invincible. With him he has associates in his Cabinet who are of the very highest order of intelligence and morals.

And so, gentlemen of this great industry, let us take advantage of the disposition shown in Washington by those who have proved their integrity and their fairness by being liberally fair on our part. Let us never intentionally do or say anything which is opposed to the public interest. Let us never fail to respond to any invitation on the part of the people in Washington to furnish information and to guide our footsteps or to direct our thoughts and our language in favor of justice and propriety, the observance of the laws and, above everything else, the observance of the principles of right and eternal justice.

Gentlemen, with the opportunities of this country, with the surroundings which we are fortunate enough to have, let us be patient and at the same time courageous and hopeful and confident that ahead of us prosperity is surely presenting itself, and that it is up to us to take advantage of it.

At the close of his address Judge Gary requested Mr. John A. Topping, Vice-President of the Institute, to take the chair.

The Chairman (Mr. John A. Topping): Gentlemen, the first paper to be presented is Uniform Coking Coal as a Factor in Blast Furnace Economy, by Mr. Walther Mathesius, Blast Furnace Superintendent, South Works, Illinois Steel Company, South Chicago, Ill.

UNIFORM COKING COAL AS A FACTOR IN BLAST FURNACE ECONOMY.

WALTHER MATHESIUS

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The principles of modern blast furnace practice for the production of pig iron have been so ably presented before this audience on several occasions during recent years that a reiteration appears superfluous. It seems sufficient for the purpose of this paper to call attention to the fact that the most important function of the process is the reduction of the metallic oxides contained in the iron ore. To accomplish this object efficiently requires the constant maintenance of a delicate chemical and thermal equilibrium between the reducing gases and the components of the furnace burden. The degree to which this demand is met and coordinated with maximum utilization of plant equipment determines blast furnace success. Progress as achieved during recent years is in a large measure due to the recognition of this relationship and its intelligent furtherance through plant design, furnace lines, careful guarding of stock distribution and a suitable preparation of raw materials.

Compared to these factors the so-called hearth reactions, that is the melting of the resultant iron and slag, have in a normally working furnace a secondary role and it follows that the effect of variations in their efficiency upon the economy of the process is also of lesser importance. Nor is this picture materially altered by including under this heading the combustion of the coke

carbon with the oxygen of the blast, as this reaction is always complete and of a definite thermal value.

An entirely different aspect presents itself, however, through realization of the fact that upon the hearth reactions is devolved the twofold duty of controlling the quality of the product and at the same time of absorbing and, as far as possible, compensating for irregularities of the entire furnace process. This brings about an interesting and in practice often quite exasperating conflict, because the proper fulfillment of the first requirement demands hearth conditions which become impossible of maintenance through the effects of the second obligation.

A uniformly high standard of quality demands not only governing the chemical composition of the metal so as to regularly keep its silicon, manganese and sulphur content, etc., well within the specified limits, but also necessitates the maintenance of certain physical properties of temperature, fluidity and freedom from slag emulsions. To operate furnaces in this manner it is imperative that a constant relation of hearth temperature, slag analysis and slag volume be rigidly preserved. It will be readily understood that any disturbance of the equilibrium between these factors must affect the quality of the iron and to prevent such changes is the preeminent task of the furnace operator.

On the other hand, irregularity of the furnace process always entails variations in the relative amount of burden materials entering the hearth, in their chemical composition, temperature and degree of preparedness and thereby invariably disturbs this balance; the greater the range of such "swings" which the furnace man must anticipate, the farther is he compelled, for the sake of safeguarding hearth conditions, to deviate from the path of most economical furnace work. To minimize fluctuations in slag analysis, the operator must increase the slag volume; and to insure adequate sulphur elimination, he must raise the basicity of the

slag; to compensate for temperature variations, he must divert the use of his hot blast equipment from its principal duty of supporting the economy of the reducing work and apply it as a heat regulator for the melting zone. Each one of these steps, which are collectively termed the "safety margin" of blast furnace operation, is distinctly uneconomical by virtue of the fact that their effect is not confined to the hearth reactions but involves the reducing zone as well. Increased slag volume means not merely more melting but lower production, because the slag-forming materials occupy, in the furnace stack, space which otherwise would be available for the reduction of iron ores. Higher slag basicity requires not only a higher temperature for the reduction of an equal amount of silicon into the metal bath and an accordingly greater heat input, but entails also a higher average stack temperature, which in turn means a greater heat loss by reason of an increased heat content of the furnace gases rising from the hearth and not met in the stack by a correspondingly higher heat demand. To provide the heat reserve required for the application of the hot blast equipment to the regulation of hearth temperature, it is of course necessary to operate the furnace with blast heats well below the range which is desired for best fuel economy and which the available stove capacity can furnish. Since this means of control is the only one which can be instantly and effectively applied at the discretion of the operator according to his observations of the melting process, the tendency among furnace men to normally work with rather low blast temperatures is always in evidence at plants where irregularities exist.

Verily then, blast furnace work assumes the role of the proverbial dog, which is wagged by its tail. And roused by the stimulus of the apparent importance which under these conditions the hearth reactions of the blast furnace assume, attempts have not been lacking to cure our blast furnace dog by a number of suggested tail remedies. Since they are aimed at the effect rather than

at the cause of the evil they have achieved little, if any, practical success. Yet these efforts have probably helped to accomplish the object to which this paper is devoted, namely, a more general recognition of the fact that blast furnace advancement, measured by quality of product, rate of output, and fuel economy, is still quite generally being retarded by the absence, in some of the most vital respects, of the required operating uniformity.

Uniformity, as the keynote to blast furnace success, has been sounded so frequently in recent years as to almost appear commonplace to many men not directly connected with furnace operation. Those, who have been fighting in the apparently incessant struggle for its attainment, hope to see the day when it will really deserve that name through universal acceptance of its principle as an absolute essential, not only in their own limited field, but in all of the contributory industries as well.

Yet, preaching the gospel of uniformity has not been in vain. It is a pleasure to compliment here the understanding on the part of the iron ore trade for the needs of the blast furnace industry. The comprehensive system of mining, sampling, mixing, grading and shipping ores, which is now most generally applied to an enormous volume of business transacted year by year, is an unqualified success. It has attained a state of perfection where not merely each season's shipments of the various grades average up to the contracted standard, and the receipts of each month are within the prescribed specification limits, but where every cargo is a true representative of its grade and constitutes a homogeneous lot with clearly defined properties. Here then the essential basis is laid upon which the blast furnace operator can build his arrangements to insure that, as closely as this seems possible at the present state of the art, every burden unit entering the individual furnace may within a given weight of a certain ore grade carry into the process identically the same amount of the various constituents as called for by the grade specifications. And this is the

goal which must be reached by every raw material used in pig iron manufacture before blast furnace uniformity can become an accomplished fact.

For the limestone trade it may be said in this respect that gratifying improvements have been made during recent years, but that in many instances it is still several laps behind its big brother, the ore business. While freedom from clay and other foreign substances and also uniform analysis are usually recognized as essential, the tendency still prevails to disregard the fact that for best furnace results a definite range of sizes must be maintained and that oversize stone as well as fines and dust, even if of good analysis, are detrimental and therefore undesirable. Other profitable outlets for this off-sized material must be developed by the producers in order to enable the economical production of the highest quality of flux stone.

In keeping with these tendencies, commendable progress has been made toward perfecting blast furnace blowing equipment, so as to obtain a definite volumetric efficiency and accurate speed control. Since among all the materials brought together in the furnace for the production of a ton of metal air constitutes the largest amount by volume and by weight, it will be readily apparent that, in their bearing on the uniformity of the process, arrangements which will insure the delivery at a uniform rate of a constant weight of blast for each minute of operation are of the highest importance.

In marked contrast to this constructive development stand today the conditions which still exist in and largely govern the manufacture of blast furnace coke. While the ore trade has long ago recognized that average analyses and average sieve tests, etc., alone are inadequate as a means of denoting a continued standard of fitness for smelting purposes and that it is necessary as an essential requirement of smelting economy to supplement such data by a rigid control and shipping system so as to insure the combining of possibly variable con-

stituents into a homogeneous aggregate, of which thereafter the blast furnace charges constitute merely smaller but equally homogeneous parts, furnace coke and coking coal continue to be produced and sold on the basis of average analyses, covering periods of months or even years. The multitude of sins which such figures are apt to cover in spite of their often most presentable showing is seldom realized. Carload and trainload lots may show variations which most seriously affect blast furnace work; yet, in the absence of adequate methods of record and control, their identity is lost to an increasing extent, the greater the aggregate tonnage included in the average data, of which they are a part.

A wide range of irregularity is in fact the outstanding feature of the blast furnace fuel supply at a majority of plants. The discrepancy in this respect, which so generally exists between the coke and all other raw materials is so prominent, and so vital is the betterment in the economy of blast furnace work which it seems reasonable to expect from the possible improvement in fuel regularity, that the necessity of a closer cooperation of producers and consumers of blast furnace fuel is undeniable and its accomplishment at an early date inevitable.

The urgency of a prompt adjustment is of course greater in districts where, on account of high fuel prices, long railroad hauls of coal or coke, high coking costs, etc., the fuel expense per ton of pig iron is comparatively large and where, therefore, the savings to be effected by a reduction in the fuel rate are relatively great. But even in territories enjoying the advantage of lower priced fuel, the possibility of increasing the productive capacity of existing furnace plants, which as an acknowledged fact is within wide limits inversely proportional to the coke rate, should warrant careful consideration of the following:

1—Coke ash is as a rule of a silicious nature and through combination with the fluxing materials becomes during the melting process a part of the blast furnace

slag, in exactly the same way as other non-metallic constituents of the burden. Variations in coke ash, therefore, cause a disturbance of the hearth equilibria and accordingly affect the blast furnace process just as has been described at the beginning of this paper with reference to raw materials generally.

2—Coke is in the blast furnace burden the principal source of sulphur, the satisfactory elimination of which in the furnace hearth requires a definite combination of temperature, slag composition and slag volume. With temperature dictated by pig iron specifications, it is obvious that sulphur entering the process in excess of the amount which the available slag volume of a given basicity can absorb, is transferred to the metal, reducing its sales value or its usefulness for steel making purposes. Coke of irregular sulphur content demands, therefore, a costly increase of the safety margin in blast furnace practice.

3—Every variation of the ash content in the coke is necessarily accompanied by a corresponding change of its carbon percentage and fuel value. This magnifies the effect on the blast furnace work of a given irregularity in coke as compared to that resulting from an equivalent change in the ore burden, since in the latter case all variations are confined to the negative side of the heat balance, which means further that at times a tendency to automatic compensation is possible.

4—Irregular ash content of furnace coke denotes variations in the composition of the coal from which the coke was produced. Charging irregular coal in the ovens always varies the heat requirements of the coking process and therefore disturbs its thermal balance, the accurate maintenance of which is a most important prerequisite to the making of physically uniform coke. In spite of a regular heat input and otherwise best practice, the production of coke with variable physical characteristics becomes unavoidable. This physical irregularity has a serious effect on blast furnace economics, because its in-

fluence is not confined to a disturbance of the equilibria in the furnace hearth, but extends directly throughout the entire furnace process. Non-uniform coke size creates irregular distribution and varying permeability of the stock column; uneven stock descent and uncontrollable flue dust losses result. Complete and timely reduction of the ore charges becomes impossible, and a heavy demand arises for solid reduction carbon and for a large amount of additional heat to cover the greatly endothermic effect of this reaction. Hand in hand with severe changes in the rate of combustibility goes a varying vulnerability of the coke to solution by the CO_2 content of the furnace gases, depriving the process of another irregular share of the fuel as originally charged to supply its legitimate needs.

Here we are confronted with blast furnace work at its worst, and often so in the face of a most attractive set of average coke analyses. Intelligent operation, the best of plant equipment and furnace lines, become checkmated and can do no more than to ward off serious difficulties. The furnace man's much emphasized preventive talent is helpless except for providing in his operation a very large margin of safety with poor fuel economy and a reduced output of often inferior product. At the same time he finds his curative efforts taxed beyond their capacity by an endless chain of troubles with guesswork, sometimes erroneously called intuition, as his only and frequently deceitful guide. And even in blast furnace work a pound of cure is quoted today at a very low rate of exchange.

To illustrate the fact that irregularities of raw materials, which may vitally affect blast furnace economy, are not ordinarily discernible from average analyses, typical data have been collected from recent operating records of one of the larger American coke and iron producers. It will be seen that on the basis of "average analysis" there is seemingly no more room for criticism pertaining to coke manufacture than there is with regard

to ore receipts. Variations in ash content, as indicated by the daily coke analyses, cover approximately the same range as the irregularities in the percentage of silicious gangue present in similar tonnages of iron ores.

However, each individual ore cargo, containing a large number of carload units of possibly varying composition, has been made up under a definite mixing plan from known quantities of previously determined analysis. Consequently it constitutes upon arrival at the furnace plant a homogeneous lot, fully representative of its grade as a whole as well as in part.

That in the manufacture of the coke a like guiding hand has been absent may be gleaned from the data on ash and sulphur in the coal mixture from which the coke was made, and more clearly still from the corresponding daily and carload analyses of the individual coal grades. Here it must be realized that the individual coal grades pass carload after carload, in an order determined only by railroad delivery, through the coal handling plant. The customary holding capacity of intermediate receivers and also of the bins for the finished mixture is limited and the coal passes through them in a virtually continuous flow. As a means for automatically recompensing successive irregularity this equipment is thus necessarily ineffective. The range of variations may be narrowed at times through accidental compensation or widened in the same way and through imperfect proportioning or subsequent segregation, but never is it possible with this method of handling to prevent the entrance of such variables into the coke. In addition, irregularities in ash content existing in the coal become magnified during the coking process in inverse proportion to the coking yield through elimination of the volatile coal constituents.

These fundamental contrasts between the practice of the iron ore trade and the coke manufacture must be clearly remembered in order to enable a correct interpretation of the following diagrams:

Fig. 1 represents data on iron ore as taken from the

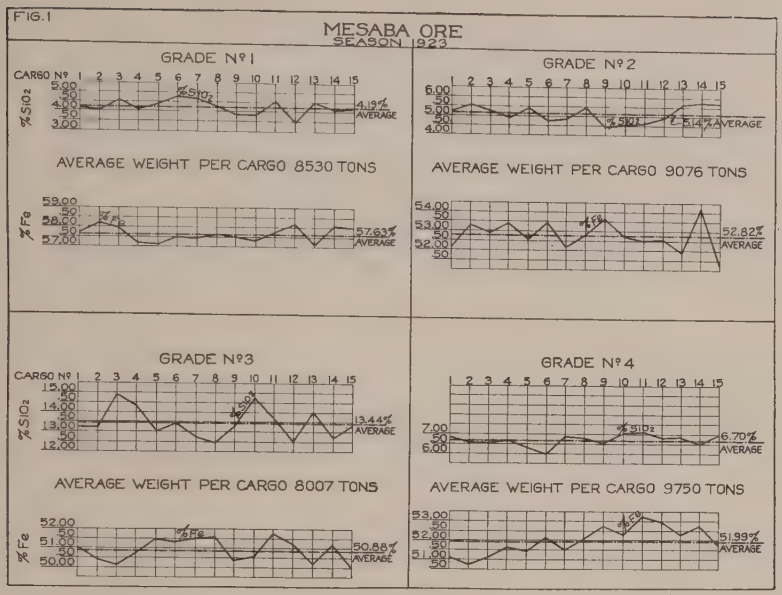


FIG. 1
MESABA ORE
SEASON 1923
GRADE Nº 1
CARGO Nº 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
% SiO2
% SiO2
4.13% AVERAGE
AVERAGE WEIGHT PER CARGO 8530 TONS
% Fe
% Fe
57.63% AVERAGE
GRADE Nº 2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
% SiO2
5.47% AVERAGE
AVERAGE WEIGHT PER CARGO 9076 TONS
% Fe
52.82% AVERAGE
GRADE Nº 3
CARGO Nº 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
% SiO2
13.44% AVERAGE
AVERAGE WEIGHT PER CARGO 8007 TONS
% Fe
% Fe
50.88% AVERAGE
GRADE Nº 4
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
% SiO2
6.70% AVERAGE
AVERAGE WEIGHT PER CARGO 9750 TONS
% Fe
51.99% AVERAGE

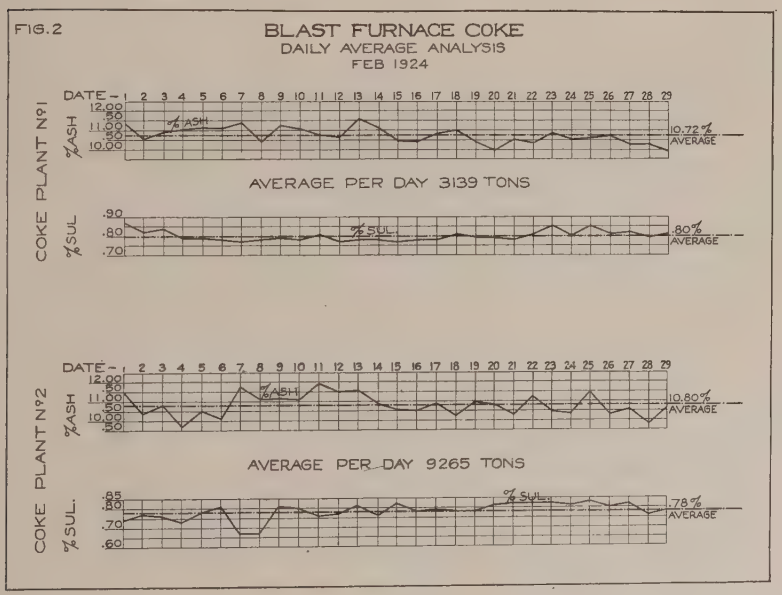


FIG. 2
BLAST FURNACE COKE
DAILY AVERAGE ANALYSIS
FEB 1924
COKE PLANT Nº 1
DATE – 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
% ASH
% ASH
10.72% AVERAGE
AVERAGE PER DAY 3139 TONS
% SUL
% SUL
.80% AVERAGE
COKE PLANT Nº 2
DATE – 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
% ASH
% ASH
10.80% AVERAGE
AVERAGE PER DAY 9265 TONS
% SUL.
% SUL.
.78% AVERAGE

FIG. 3

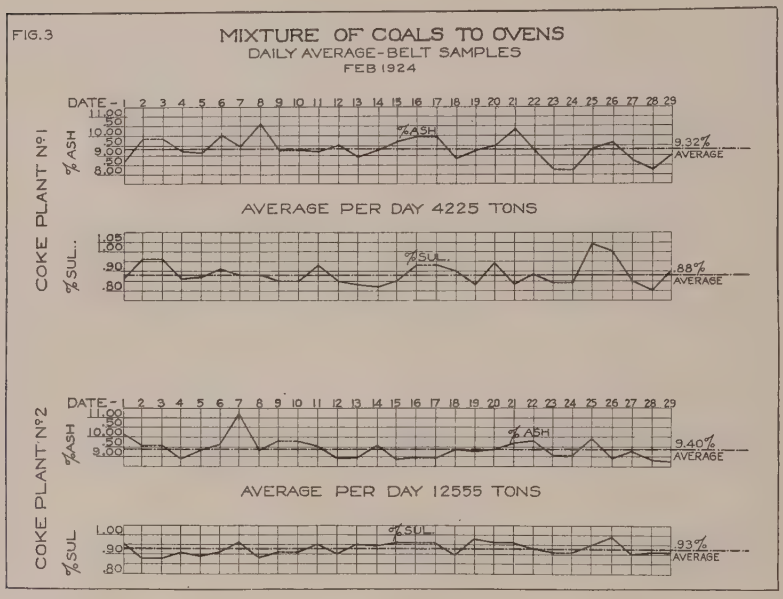
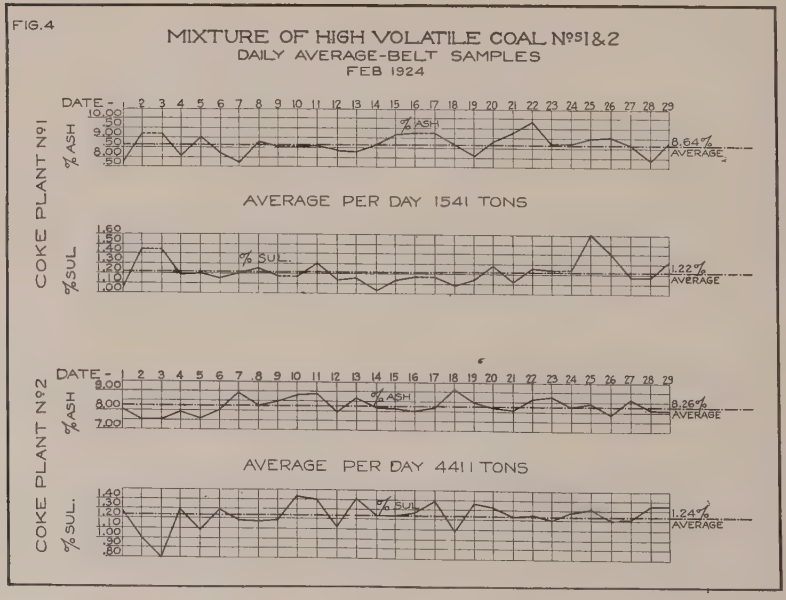

MIXTURE OF COALS TO OVENS
DAILY AVERAGE-BELT SAMPLES
FEB 1924
COKE PLANT Nº1
DATE - 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
% ASH
% ASH
9.32% AVERAGE
AVERAGE PER DAY 4225 TONS
% SUL.
% SUL.
.88% AVERAGE
COKE PLANT Nº2
DATE - 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
% ASH
% ASH
9.40% AVERAGE
AVERAGE PER DAY 12555 TONS
% SUL.
% SUL.
.93% AVERAGE

FIG. 4


MIXTURE OF HIGH VOLATILE COAL Nºs 1 & 2
DAILY AVERAGE-BELT SAMPLES
FEB 1924
COKE PLANT Nº1
DATE - 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
% ASH
% ASH
8.64% AVERAGE
AVERAGE PER DAY 1541 TONS
% SUL.
% SUL.
1.22% AVERAGE
COKE PLANT Nº2
DATE - 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29
% ASH
% ASH
8.26% AVERAGE
AVERAGE PER DAY 4411 TONS
% SUL.
% SUL.
1.24% AVERAGE

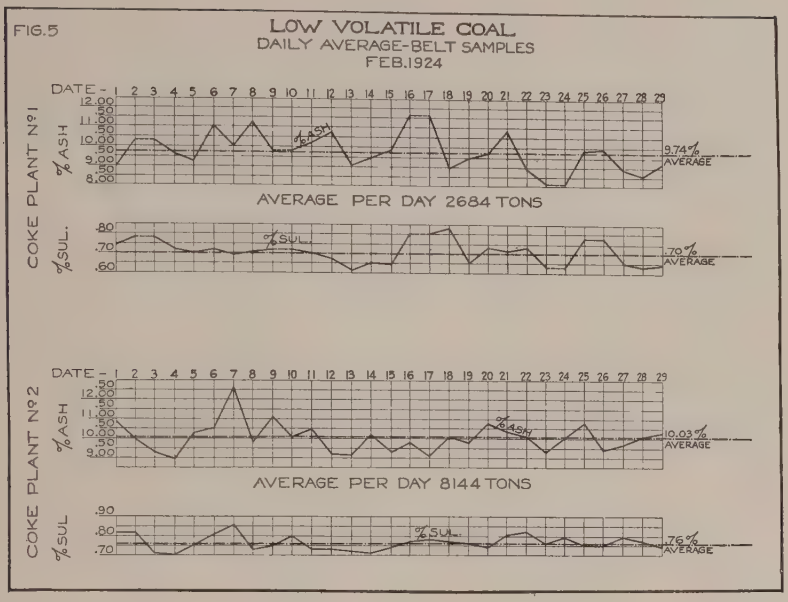


FIG.5
LOW VOLATILE COAL
DAILY AVERAGE-BELT SAMPLES
FEB.1924
COKE PLANT Nº1
% ASH
% SUL.
9.74% AVERAGE
AVERAGE PER DAY 2684 TONS
.70% AVERAGE
COKE PLANT Nº2
10.03% AVERAGE
AVERAGE PER DAY 8144 TONS
.76% AVERAGE

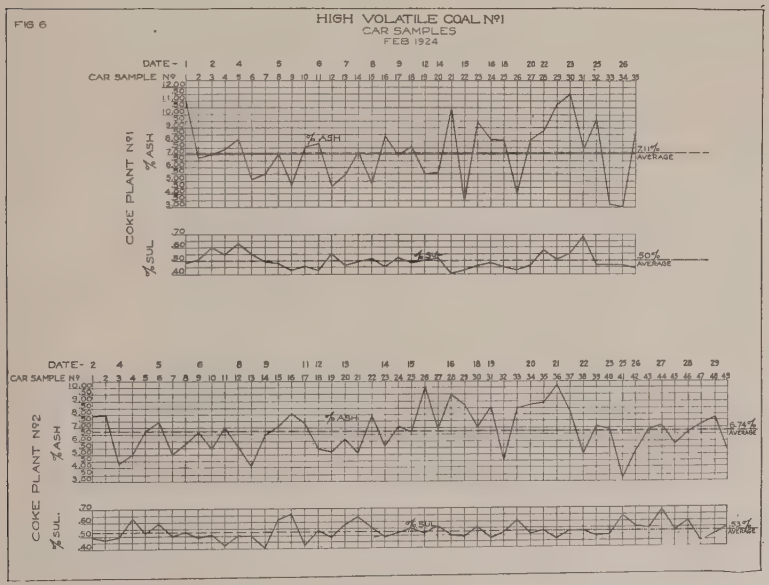


FIG 6
HIGH VOLATILE COAL Nº1
CAR SAMPLES
FEB 1924
CAR SAMPLE Nº
COKE PLANT Nº1
% ASH
7.11% AVERAGE
% SUL.
.80% AVERAGE
COKE PLANT Nº2
6.74% AVERAGE
.63% AVERAGE

FIG. 7

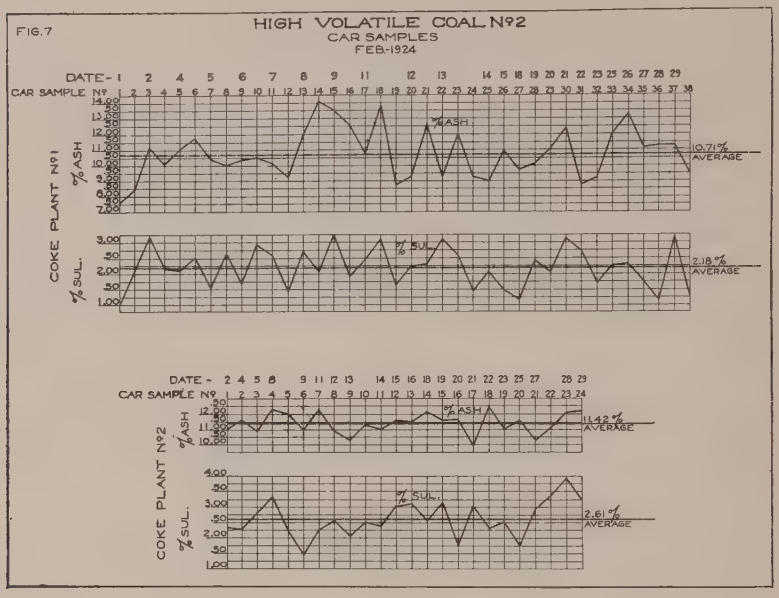
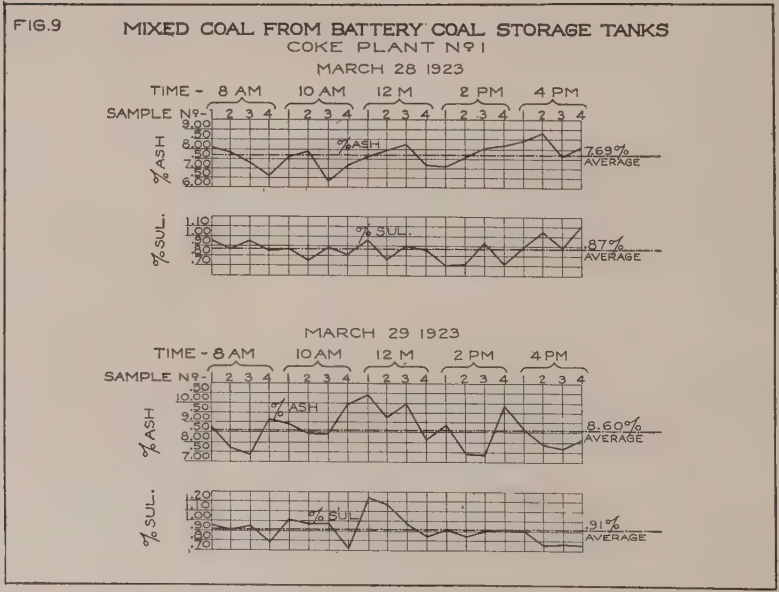

HIGH VOLATILE COAL Nº2
CAR SAMPLES
FEB-1924
DATE-
CAR SAMPLE Nº
COKE PLANT Nº1
% ASH
% SUL.
10.71% AVERAGE
2.18% AVERAGE
COKE PLANT Nº2
11.42% AVERAGE
2.61% AVERAGE

FIG. 9


MIXED COAL FROM BATTERY COAL STORAGE TANKS
COKE PLANT Nº1
MARCH 28 1923
TIME - 8 AM 10 AM 12 M 2 PM 4 PM
SAMPLE Nº-
% ASH
% SUL.
7.69% AVERAGE
.87% AVERAGE
MARCH 29 1923
8.60% AVERAGE
.91% AVERAGE

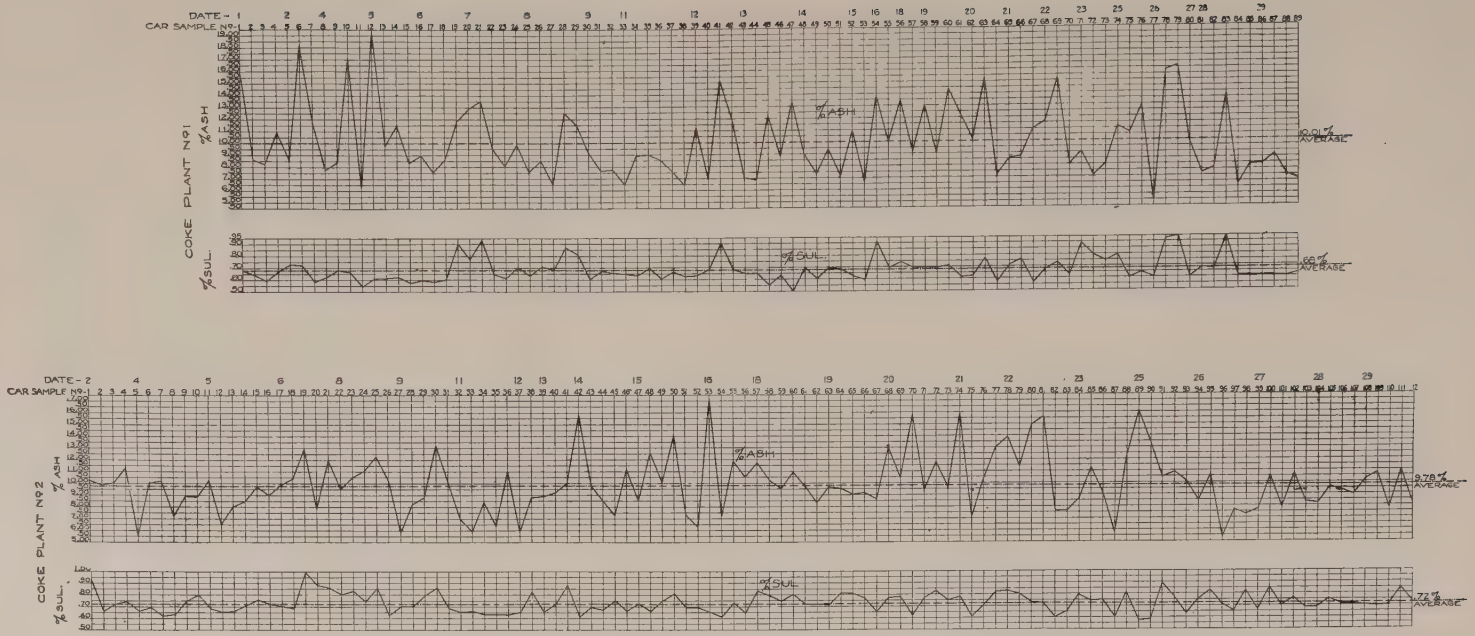


Fig. 8—Analyses of car samples of low volatile coal, February 1924

analyses of consecutive cargoes of Mesaba grades received at a lower lake port during the season of 1923.

Fig. 2 contains data on blast furnace coke taken from consecutive daily average analyses of two different by-product coke plants during the month of February, 1924.

Fig. 3 illustrates the variations in the daily average analysis of the coal mixtures at the same two plants and for the same operating period.

Figs. 4 and 5 show the fluctuations, day by day, in the average analysis of the individual component grades of coal before their combination, at the coke plants, into the finished coal mixture.

Figs. 6. 7 and 8 give the results of consecutive carload samples, for the various coal grades shown.

It may be seen that the coal diagrams indicate a greater range of variation in the carload samples than in the daily belt samples of each grade, and again more decided fluctuations in the latter than in the analyses of the coal mixture. Deducing from this apparent tendency a greater degree of regularity in the mixture would, however, be no doubt a fallacy. For the reasons advanced in the preceding discussion this must be interpreted as representing largely the leveling effect on the curves which results from including in each sample and analysis an increasing tonnage of material. Taking more frequent samples and analyzing them separately would readily demonstrate this point.

The time available to the author since this subject was suggested did not permit of gathering data in this respect for the period illustrated by the preceding diagrams. Test figures obtained about a year ago through sampling the coal in the battery charging car at two hour intervals may, however, be of interest because they are considered typical in denoting continued non-uniformity from carloads to the coal mixture. They are plotted in Fig. 9.

Aside from their irregularity an interesting feature of the curves representing analyses of coal grades is the

evident tendency of the sulphur lines to parallel the ash variations. This should be emphasized in its bearing upon the corresponding analysis of coke. It is generally known that no definitely fixed relation exist between the sulphur content of the coke and that of various coals used in coke production. Coals from different fields show a considerable range of ratios between organic sulphur compounds and the pyritic forms and all of these vary widely in their behavior during the coking process. Research work does not appear to have succeeded as yet in fully explaining these evidently intricate chemical relations. However, the fact seems fairly well established that the percentage of sulphur removal through volatilization during the coking process from coal of a certain deposit is within wide limits independent of the total sulphur content. An increase of sulphur in the coal entails, therefore, a proportionate rise of the sulphur percentage in the coke. Organic sulphur being an inherent part of the carbonaceous coal substance is usually found in a state of fairly uniform distribution throughout the latter, while the pyrites are associated with the inorganic impurities of the coal seam and are, therefore, generally present to a greater degree of concentration in the dirt bands and other high ash portions of the deposit. The variations of the sulphur lines in the diagrams as presented, denote therefore principally changes of the coal in its sulphur content, which are brought about by the inclusion in the coal shipments of varying amounts of impurities, a fact which in itself is already indicated by the corresponding ash curves. In consideration of this relation and for the sake of simplicity, sulphur has in the following portion of this article been mentioned specifically and apart from ash content only where clarity of expression made it appear necessary to do so.

If it may thus be considered established that major irregularities are encountered in the blast furnace fuel supply, and if it is realized that they are the rule rather than the exception today, the serious detriment which is

inflicted thereby on the economy of pig iron production should be clearly apparent.

There is only one possible remedy, and that is the regulation of the blast furnace fuel supply in accordance with the principles of the iron ore trade, so that as nearly as this can be accomplished with our present knowledge and ability, every coke charge entering the individual blast furnace may within a given weight and volume convey into the process the same fuel value with the same chemical and physical characteristics.

Visualizing the economic significance of the possible improvements, it is rather difficult to comprehend why their accomplishment is achieved today in only a small minority of operations. The most plausible explanation appears to be the absence of a clear understanding of the blast furnace needs on the part of coke producers and the coal mining interests.

In the days of beehive coke the ovens were usually associated with the coal mining concerns, but operations of sufficient size to supply the average furnace plant were not the general rule. This entailed a condition of divided management and responsibility, which did not promote the necessary unity of purpose. Attempts were frequently made in those days to devise a satisfactory system of grading coke shipments at the blast furnace plant. While they succeeded in a measure in regulating the consumption of coke from different sources of manufacture according to some semblance of order and subject to the promptness of railroad delivery, they were utterly unable to cope with the variations contained in the shipments of each grade. This condition persists today in exactly the same manner. Furnace coke, with very few exceptions and irrespective of whether it is received from an adjacent coke plant or shipped from a greater distance, must be consumed in the order of arrival. Railroad cars, which are the usual shipping units, are unloaded consecutively at the bins of individual furnaces and their contents reach the latter in the same order. Stock piling

or other grading operations are out of the question on account of the expense involved in handling, as well as the heavy loss of usable coke sizes and the deterioration of quality which would ensue through breakage and abrasion. Operating control on the basis of frequent coke analyses and physical tests, which theoretically might seem possible, is not feasible owing to the difficulty of obtaining reliable data with the required speed and of promptly adjusting furnace conditions accordingly. To be at all representative, samples must be taken during the unloading operation, whereupon their analyses are, of course, secured too late for operating purposes and become a matter of record only.

The advent of the by-product coke oven and its rapid rise to a position of undisputed supremacy over its old time competitor appeared to give promise for a time of affording the means for a permanent solution of the problem. With the erection of the new coke plants in proximity to the consuming blast furnace and steel works, the chances for closer cooperation between coke producer and consumer were evidently much enhanced.

With full appreciation, however, of the wide scope of coke plant activities, the many and delicate intricacies of its construction and production problems and the vast amount of detailed watchfulness required in the operation, it is felt that these questions and the effect on the coke quality of the many possible variables in coke oven performance are subjects beyond the scope of this discussion.

Following the natural course of coke plant procedure, coke is loaded and shipped in the order of production. To be effective in the coke, uniformity must therefore be an established characteristic of the coal mixture. To continuously insure in this the highest possible degree of regularity by diligently handling and mixing the several coal grades is, of course, a task, for which the responsibility rests clearly with the coke plant organization. It is evident, however, that this obligation must be confined

to the proper crushing and the mixing of various grades in fixed proportions, and that it is impossible at this point to take care of or attempt to compensate for irregularities of each constituent. To sample and analyze coal receipts and thereafter to grade them accordingly by handling through stock piles or bins can evidently not be contemplated at present in view of the delay to railroad equipment which it would entail and the large expenditures required for erection and operation of storage plants and handling facilities of adequate capacity.

It seems pertinent, however, to here call attention to the fact that practically every coke plant is now equipped with coal storage facilities. Such installations might contribute at times to economies by providing the opportunity for buying larger tonnages of coal during periods of price recessions and for taking advantage of cheaper water transportation during the summer season, but their principal function is the maintenance of an emergency supply to guard against contingencies which might interfere with the continuous operation of the plant. From this angle, coal storage plants are usually considered a necessary evil, representing in normal times an idle investment. Their operation adds to the coke plant expenses and is, therefore, to be confined to emergencies and to such times, separated by the longest possible intervals, when the turning over and replacing of the stock becomes necessary on account of deterioration in coking quality, heating and possible firing of the old coal. The serious effects on blast furnace performance which invariably follow during these periods seem to amply justify the odious repute in which stock coking coal is held today among blast furnace men.

Yet it appears to be entirely feasible to convert these storage plants into valuable assets to the industry by arranging them so as to permit of simultaneous stocking and recovering and by thus passing the entire current coal requirements of the coke plant continuously through the stock piles. It is evident that in this way the neces-

sity of periodically having to use aged and deteriorated coal would be avoided, but at the same time tangible advantages would accrue to the coke plant by making it in a large measure independent of prompt railroad delivery and continuous unloading of coal, saving demurrage bills through the opportunity for quickly handling excess shipments and preventing interference with coke oven operation, such as might result from inability to unload coal at the required rate during periods of adverse weather or of labor shortage. Summing these items up and adding to them a most conservative estimate of the improvement in blast furnace economy, which would unquestionably follow, it appears safe to predict that the proposed coal handling method would be a profitable investment in many instances.

This development is not purely theory but has been demonstrated to the author's knowledge through the successful practice of at least one well known concern. Incidentally, an arrangement of this kind places the coke plant piles in the same profitable position as aids to greater blast furnace regularity, which is now quite generally realized from proper utilization of blast furnace ore stock piles throughout the year, although they were originally provided for the storage of the winter supply only. Judicious stocking and reclaiming plans, devised first as a mere preventive against segregation of coarse and fine material, have grown to become important factors in the maintenance and for the improvement of regularity in ore grades. Parallel advantages would no doubt accrue to blast furnace practice from the operation along similar lines of coal storage facilities at the coke plant.

It has, however, been clearly demonstrated that methods for handling and storing ore at the point of consumption can in no way become substitutes for the mining and grading control. Likewise, efforts of the coke oven operator and possible improvements in his plant facili-

ties do not detract in the least from the necessity of commanding uniformity in coal shipments.

To insure this is the obligation of the coal producer. He must be convinced that the attainment of best ultimate results depends upon the establishment and maintenance by him of an adequate mining and shipping system and that this is feasible.

The consumer must recognize that buying coal with weight as the only specification does not pay and that it would be true economy on his part to encourage efforts toward clean mining and uniform shipping grades through adequate compensation for special care taken by the producer in furnishing a fuel of superior value.

Actually, coking coal, as supplied to a large part of the industry is being mined, sold or accounted for and converted into blast furnace fuel with little or no regard for the requirements of the process in which it is to be used. Constancy of grade is not recognized as essential and adequate control is lacking to insure a definite degree of uniformity. Frequently coals from separate veins with different coking qualities and analyses are mined, shipped and used promiscuously for coke making under the same name. "Pocahontas," "Smokeless," "Elkhorn," and "Kentucky" are collective nouns in this sense rather than brands denoting coals of certain well defined properties and composition.

The author does not pretend experience in the mining of coal nor does he claim the qualifications required for stating definitely to what extent this demand for clearly defined and uniform shipping grades can be met by the coal producers under the present practice of making direct carload shipments from individual workings to the coke plant. He prefers, therefore, to confine himself to certain observations from the standpoint of the consumer, which it is hoped will serve to elicit from the producer a statement of his expert views, showing how modern developments in the coal industry expect to take care of this problem, and with particular reference to

such items as sampling and grading or grouping, wherein the successful precedents established by the practice of mining and shipping iron ores seems to fairly urge their duplication in the coal fields.

In a recent paper* presented to this Institute on modern methods of mining coal, the author describes interestingly and endorses fittingly the efforts and the success of the coal mining industry toward safer mining, lower operating costs, increased application of mining machinery and especially toward greater coal recovery from a given acreage of coal land. No mention is made, however, of possible developments in mining practice which might enable or promote a better economy in the utilization of the fuel. As applied to coking coal from a given deposit, this concerns first of all the subject of clean mining and of uniform shipments. And yet the fact can be readily shown that in some of the most striking examples increased coal yield has gone hand in hand with an increase in ash content, and what is still more noteworthy with a serious increase in ash irregularity. Since these entail not only wasted expenditures for transportation but grave disadvantages to the consumer through decreasing the productiveness of his plant equipment and increasing the fuel consumption per ton of iron at a much faster rate than indicated by the average rise in ash percentage, it must be realized that increased yield of mining from a given coal acreage might eventually represent no gain but actually constitute an important loss in ultimate overall fuel economy.

For a closer study of this situation the coal producers might be considered as divided into two groups, those selling their output on the open market and those who, more closely affiliated with consuming interests, are furnishing coking coal to certain consumers exclusively. Under otherwise comparative conditions the former class, because of trade competition, is more directly confronted

*Modern Methods of Mining Coal by H. Foster Bain, Yearbook, American Iron and Steel Institute, 1922, p. 301.

with the necessity of guarding the quality of their product to the satisfaction of their customers, in order to maintain their market and to enhance the sales value of their product.

For the associated companies, the principal factor serving as a sole index to mine efficiency is only too often the cost per ton mined. Efforts toward cleaner mining, through increase in labor expended and reduction in tonnage shipped, must however necessarily increase the mine cost per ton. And it seems obviously unfair to expect the mine manager's consent to an increase in their operating cost by which their own efforts are chiefly and commonly judged, unless other equivalent opportunities be given for appropriate recognition of their services.

The fact results that in many instances coal is produced from affiliated mines at a lower cost but of an inferior quality than is obtained in the same fields by independent concerns. Differences in labor conditions, which are sometimes quoted to account for this discrepancy, cannot be considered as valid reasons. Miners are not seldom found to prefer working in the often larger affiliated mines with better mining equipment, better ventilation, better living conditions and which in addition have frequently more assurance of continued operation. Working rules for the two groups under discussion are nominally alike; not so, however, in actual practice. For example, the constant enforcement of docking schedules arranged so as to make it of pecuniary advantage to the miner as well as to the mine management, to produce clean coal is found to be confined largely to the independent concerns. The conclusion seems inevitable that here miners as well as management are more directly interested in keeping the ash content of their shipments as closely as possible down to the analysis of the coal seam from which they are produced.

With this contrast before us, a comparison of the cost to the consumer for hauling slate out of the mine, paying railroad freight, coking, melting in the blast furnace and

ultimately landing it on the blast furnace slag dump, with the cost to the coal mining end of the business for separating the slate from the coal and leaving it on the gob pile seems to clearly reveal the need of improvement and also the most logical point of attack.

In the author's opinion, the required remedy consists in applying to the mining company's cost sheets the same principle which is embodied in the docking schedules for the individual miner. In other words, it is suggested that coking coal shipments be accounted for on the basis of a fixed ash percentage, agreed upon for each grade of coal handled, and that penalties be attached for higher ash as well as irregularities beyond a definite range, and premiums granted for lower ash content by subtracting or adding tonnage as credited to the mine. It is believed that this accounting tonnage could represent an equitable measure for value received by the consumer and at the same time for the efforts of the mining organization toward producing from its coal acreage a maximum output of the highest grade fuel aiming at best ultimate economy rather than merely lowest cost per ton of material brought to the surface. Coordinating in this manner the interests of the mine management with those of the individual miner should produce the desired end.

The proposed accounting method is not as novel as it might seem. A comparison will readily show that it is based on the same principle as the universally established practice of trading in iron ores. The object of its system of unit values is a fair price per ton dependent upon chemical as well as physical properties and adjusted according to the amount of various impurities present. While the schedule as now in force may not be in every respect a fair and equitable arrangement, its value to the entire industry is undeniable. Constructive forces are constantly at work on its perfection with due consideration to the interests of the producer as well as the consumer. Nor does this system appear to impose disadvantageous restrictions, since it leaves the ultimate

price settlement to the directly interested parties who may take into account many special factors in arriving at the final contract.

For the reduction of ash and the insuring of greater uniformity, considerable work has been done in the development of mechanical coal cleaning plants. The blast furnace man should welcome such equipment, provided that by its means an improvement in coal quality can be obtained at a cost commensurate with the attendant increase in value and provided further that the installation be of ample capacity and reliability to insure the continuous treatment of the entire mine production and not only of perhaps a variable part of it. It will be apparent that in the latter case a possible decrease in the average ash content of the monthly shipments might be accompanied by a decided increase in the range of variation, which through its detrimental effect on blast furnace practice might easily offset the advantage of the lower ash. Calculations to prove the financial justification of installing and operating coal cleaning plants on the basis of an expected reduction in the average ash content should carefully consider this possibility.

Another factor of importance which is sometimes lost sight of is the extent to which the ash content of the coal as actually shipped is above the ash percentage which would be obtained from the same coal seam by careful mining. It is evidently the latter figure which should be used as a basis in the discussion of plans for mechanical coal cleaning together with corresponding data on the degree of irregularity which might still be evident in the coal mined under these conditions. While all efforts toward greater uniformity in coal should be most heartily encouraged, the installation of mechanical cleaning plants should not be considered as a "sine qua non." On the contrary, a number of independent producers and some others as well in various coal fields have established the fact through their practice over years of successful operation that coal as furnished for coking purposes by the

principal districts today can be mined as a uniform product with ash low enough for best blast furnace results, and without excessive production costs, when viewed from the standpoint of ultimate economy.

It is understood, of course, that these comments on the question of mechanically cleaning coal are confined to the attainment thereby of a uniform shipping grade, where a reduction in the average ash or sulphur content is not the primary object although it would no doubt be one of the incidental results. The broader field of applying coal cleaning processes to the reduction in ash, sulphur, etc., in coal from admittedly impure seams, so as to make them available as metallurgical fuel, or in other words, of increasing by mechanical cleaning the value of a carefully mined coal to an extent appreciably in excess of the cleaning cost, is considered as outside of the scope of this discussion.

The thought of being able to mine a coal seam with a minimum of skill, care and supervision and thereafter to obtain a uniformly good shipping grade through mechanical cleaning has unquestionably many attractive features to the mining man. But even with such facilities installed it must be borne in mind that the cleaning capacity of a given equipment, the cost of cleaning per ton of coal shipped and also the yield of the cleaning operation are adversely affected by an increase of impurities in the raw coal. Thus, a cleaning plant does not compensate for loading out everything in the mine "as it comes," but should rather be an added inducement for the constant enforcement of a just docking rule.

To obtain better coking coal from the mine the intelligent and willing cooperation of the coal consumer is absolutely necessary. He should come to realize that his usual attempts to exert some pressure on the producer through the occasional rejection of particularly bad lots of coal cannot be generally effective, even though they should bring about an improvement at times and for a certain contract. The loss of revenue suffered through

such procedure by the producer, including demurrage charges, rerouting, rehandling and price concessions must eventually be borne by the consumer. Particularly in the case of coal shipments from mines to affiliated coke plants and blast furnaces, the futility of such procedure will be apparent without further comment.

It may be confidently expected that a vastly more satisfactory arrangement would result from the adoption of the proposed plan to adjust coal prices, or tonnages credited, on an analysis basis and in proportion to the fitness of the deliveries for their intended use; intelligent arrangement of sliding scales should profitably promote the chances for better coal and greater constancy of grade.

Many years of persistent effort in training and educating both producers and consumers of iron ores have brought about the benefits accruing today to the steel industry of the country from the universal functioning of the established mining and trading system. The natural difficulties which have confronted the ore mining man in this work, such as the great variations in the physical and chemical character of deposits often contained in the same mine, or in many cases the necessity of wholly seasonal operation, are infinitely greater than might be anticipated in the majority of coal mining enterprises upon which our blast furnace plants depend for fuel. Inauguration of a similar system in the coal industry does not therefore by comparison appear to be fraught with insurmountable obstacles.

For an adequate return from the efforts which it is herewith suggested be put forth by the purveyors of blast furnace fuel, the blast furnace industry must evidently hold itself largely accountable. It should reflect the improvement not merely in a greater ease of performance but in a better quality of product, greater output and decidedly better fuel economy. To forecast the probable extent of these benefits by means of theoretical calculations would no doubt be of interest, provided it could be

accomplished with a sufficient degree of accuracy and without numerous assumptions and assertions. It seems questionable whether this could be done until commonly understood and in their economic effect thoroughly explored mathematical expressions have been devised to denote varying degrees, durations, cycles, etc. of non-uniformity in fuels. To the coal mining interests which at times express a desire for such theoretical figures as a guide by which to determine the justification of contemplated changes in working methods, or of proposed investments, I suggest instead, for the sake of expediency as well as accuracy, the method of practical demonstration. Examples, past and present, are available in sufficient numbers to show what can be done under otherwise equal conditions of raw materials equipment and practice by a handling of the fuel requirements in accordance with the best interests of the blast furnace process.

Most pig iron producers who are not at present enjoying such advantages in the operation of their plants can point to past performances under more opportune fuel conditions with a pride in which it would be eminently fitting to allow a liberal share of credit to the coke plant and the mine management. But steeled rather than wearied by their years of struggle for uniformity's sake, blast furnace men stand ready to surpass their records. To this end they solicit the earnest and hearty cooperation of the coal mining man.

The Chairman (Mr. John A. Topping): There will be a discussion of this paper by James B. Pauley, Vice-President, J. K. Dering Coal Company, Chicago, Ill.

Discussion by James B. Pauley

Vice-President, J. K. Dering Coal Company, Chicago, Ill.

It is a real privilege for any coal operator to have the opportunity of discussing a paper which so clearly sets forth the advisability, economy, even the necessity, of uniform fuel.

Every one engaged in production, no matter what the commodity may be, has an underlying ambition to produce quality. If force of circumstances, competition, requirements of the market, or other elements make it necessary that price be the predominating influence, there must still be the same desire for quality, and a regret that it is impossible of realization in its fullest sense.

It seems possible to ignore the intermediate process between the mining of coal and the charging of the fuel into the blast furnace, as the elements of impurity undergo no material change in the coking process that needs to be considered in this discussion.

The coal operators could have no disagreement, because of the facts or because of desire, with the practice so ably presented by Mr. Mathesius in his treatise. This seems to emphasize the fact that it is not so much a question of the actual quality of the fuel as it is of its uniformity. It is perhaps not a complete exaggeration to say that uniformity throughout, even though the quality be poor, within allowable limits, is preferable in blast furnace practice to a wide range of variation, even though the general average should be better.

The paper under discussion in a way seems to suggest, but does not advocate, some method of controlling the variations through the mixing and distribution of the impurities throughout, rather than reaching the same result through their reasonable elimination. The sampling, mixing, and grading of ores as they are passed through pockets, thence into large cargoes, and later handled over a stock pile in the natural course, is quite different from anything that would be feasible in handling coal, either at the point of shipment or consumption. It may be said that these things can be done, but are scarcely practical. Car sampling and resultant analyses for such purposes are so unreliable as to be at least very misleading, and would go far to defeat the effectiveness of a scheme to mix through stock piles.

In the process of coke manufacture, if it is necessary in order to obtain structure, or for other reasons, to employ fuels of a different nature, then, of course, a proper mixture of the essential elements is imperative, but it would seem to be a fallacy to go to the expense of mixing any one class of fuel for the sake of equalizing a distribution of its impurities. In a way this might even be classed as degrading, or, to say the best of it, it would incur a substantial expense without improving the average quality. It would be possible to accomplish exactly the same result, as to uniformity, in a very much more effective and convenient way and at the same time enhance value by the elimination, in some degree, of impurities. It would be difficult to say, in a general way, what the comparative cost of the two methods might be, but it is safe to say that grading, by elimination at the mine, would be altogether practical, whereas there would seem to be no practical way, or no proper place, either at the mine or at the point of consumption, to conveniently grade by a mixing process, as indicated. In any case, the benefit derived would surely stand as a large item in favor of the more logical proceeding.

It has been fully demonstrated that it is necessary to eliminate the extraneous impurities by some process, and that it is expensive, impractical and inefficient to attempt to do so in blast furnace practice. Evidently there has been considerable expected of the blast furnace, which was presumably designed for other functions than that of handling the excessively impure and variable fuel, particularly when these undesirable elements could be reasonably controlled otherwise, at a reasonable cost and under circumstances which would be productive of less danger of substantial expense.

The art of cleaning coal, if it may be termed as such, has not been as progressive as many others, partly due, perhaps, to the many difficulties involved, including the undesirability of rehandling, so far as possible, but principally to the limitation set by the expense involved.

The hypothesis may be accepted as a basis that anything can be accomplished within reasonable limits in the cleaning and preparation of coal, that is to say, the impurities which are not inherent in the coal can be taken out. A specific discussion of this subject, sufficiently brief to be interesting, gives rise to ample grounds for disagreement and argument, because of a considerable variation in the amount of impurities, in the form in which they are found, and in the treatment necessary for their elimination. These conditions vary in different districts, they vary in different veins, and, unfortunately, they even vary in the same seam and in the same mine. This statement of indisputable facts is rather trite but furnishes ground for declaring that it must be understood that a discussion of this kind must necessarily be very general in its terms and presupposes always the element of reasonable limitations.

As to the question of purification by mechanical means it may be said that it is possible to eliminate all of the extraneous ash-producing elements, and this statement may be taken almost literally. If fuel is to be cleaned outside the mine, it is necessary to provide facilities for so doing. The cost thus involved might run to a considerable amount, depending upon the degree of perfection required. It is not the purpose of this argument to go into the question of the various means of doing this work, as they are too varied and complicated in their scope and depend too much upon the wide range of conditions to be encountered.

It should be admitted that the natural and logical place of grading fuel is at the mines. It would seem to constitute one of the operations of mining. There is no good reason for handling, loading and transporting impurities to the point of consumption, unless they can be more efficiently and economically eliminated at that point, which is not apparently the case. Carrying this thought still further, the best place for the elimination of the impurities is in the mine, at the face. There is no point

in incurring hoisting or haulage charges, and the cluttering up of expensive equipment outside by a failure to clean the coal, within practical limits, at the point where it originates.

There are but two methods of accomplishment at the face, that is to say, supervision and disciplinarian action. That both of these have the direct effect of adding slightly to the cost of production is obvious. Through supervision it is possible to help the standard of fuel, both in the control of the machine runner, where mining machines are used for under-cutting, and in the loading of coal. That substantial improvements can thus be obtained is a matter of experience. That carelessness in loading is within the control of the men, without undue hardship, is demonstrated by the fact that in exercising the docking privilege it is usually shown that some men are never guilty, whereas others are habitually so, even where there is no difference in the conditions under which all are working.

The claim of these arguments is that the greater the degree of purification, the less variation. If carried to a point approximating perfection, the variation would be confined within such narrow limits that it would cease to exist for all practical purposes in blast furnace practice.

After this discussion of the mechanical features involved in the various theories it is perhaps in order to make brief mention of commercial elements, which have a large influence on this proposition.

In the event of the outright purchase of coal for the purpose under discussion, it is difficult in negotiation to demonstrate a substantial value, on account of quality, as between two fuels, either of which will do the work required. The hope is that it has been demonstrated in these remarks that it is possible to reach satisfactory results as to quality and uniformity, and that the effort should command a price commensurate with the cost.

In producing fuel by one company, for the use of an

associate company, where in a way the allotment of expense is more or less a matter of bookkeeping, the element of human nature must be considered in these interdepartmental relations, when each representative head is called upon to make the best possible showing for his department.

Treating with the two illustrations just cited, it may be said that oftentimes the individual who discusses the purchase price on one hand, or the cost of production on the other, is, in theory, not so much interested in the expense which will accrue further down the line and which, after all, is a charge, one way or the other, on the ultimate consumer. The general inference drawn from this is too obvious to require the time of discussion.

The conclusion of the arguments attempted is that since there must be an expense at some point in the operations of the consumer, it would be logical to ascertain where and how the necessary corrections could be most economically and effectively handled and let the charge occur at that point in the process where it would be least costly to the consumer, who must eventually, directly or indirectly, bear the charge.

The Chairman (Mr. John A. Topping): There will be a further discussion of this paper by Mr. Henry R. deHoll, Superintendent of Coke Ovens, Inland Steel Company, Indiana Harbor, Ind.

Discussion by Henry R. deHoll

Superintendent of Coke Ovens, Inland Steel Company, Indiana Harbor, Ind.

The paper which Mr. Mathesius has just presented is a courageous stand against a practice too frequently followed, of providing by-product coke ovens with coals so constantly varying in their chemical and physical properties as to destroy the first essential quality of the resulting coke; uniformity. He has categorically set forth the reasons why and how the composition and

characteristics of coke affect the economy of the blast furnace, and appeals alike to the coal producer, the coal consumer and the coke plant operator, to join hands in devising and adopting ways and means to provide the blast furnace with a metallurgical fuel more uniform in chemical composition and physical characteristics than at present seems to be the case.

The remedy he seeks is presented in the form of several suggestions. He suggests adjusting coal prices and tonnages on an analysis basis, similar, I presume, to the Government method, by which for coal delivered which is of better quality than the standard, the producer is paid a bonus, or credited with a tonnage proportionate to the increased value of the coal, and for deliveries of coal of a poorer quality than the standard, deductions are made from the price or tonnage, as the case may be, proportionate to the decreased value of the coal.

The advantages of such a system, to at least one of the contracting parties, are clear, and while I am not a judge of the difficulties and obstacles in the way of the adoption of such a plan, the fact remains that such a system is in operation, and the advantages therefore must be on both sides.

Uniformity of coal is as essential, possibly more so, to the production of uniform coke as it is for almost any purpose for which coal may be used, and if coals greatly varying in their constituents are used, the economy of the coke plant is adversely affected, perhaps not as vitally as the economy of the blast furnace is affected, but just as certainly.

Another suggestion is the grading, classification, and distribution of coal, in a manner similar to the practice used in the production of iron ore. Comparing the results of former days with the present, none can deny the enormous benefit derived from the present system of mining and grading ore, and if the same intelligence and determination were employed towards the raw material

of its blast furnace companion, similar results may confidently be expected.

A third suggestion is the reconditioning of present coal storages, or the establishment of new ones, with equipment tending to eliminate the necessity of periodically using old and new coals. His recommendation in this respect is rather vague. If he refers merely to facilities for simultaneously stocking and reclaiming, providing the method of handling be approximately as described later on, I am wholly in accord with his proposal, but a word of caution seems appropriate if he refers to plans for coal storage whereby the coal would be deposited as is general practice now, but where the reclaiming would be done by a system of conveying belts underneath, so that the coal overhead is a constantly moving column, always depositing on the belts the oldest coal. It appears to me that, for small stock piles, the expense would not be warranted, and that, for large stock piles of hundreds of thousands of tons, the cost of installation would be prohibitive. Besides the initial cost, attention is directed to the danger of admitting air currents to the bottom of the pile. If air is sufficient to permit oxidation, but not sufficient to carry away the heat as rapidly as it is formed, the temperature will rise and the coal will fire. In piles forty and fifty feet high, which is not unusual in large coal storages, I would consider periodical admittance of air to the bottom rather risky.

I have the privilege of serving a company in which the suggestions and recommendations submitted have received considerable attention for a period of years. This company belongs to both classes into which Mr. Mathesius divides the coal producers; the class that sells coal in the open market and the class that mines coal for its own coking operations. With due respect for the opinion expressed, that there is a greater incentive for the former class to mine clean coal uniformly than there is for the latter, I wish to state that coal received at our coke plant comes exclusively from mines which furnish

a product of proven coking qualities, and of uniform character. The first consideration in the operation of those mines is not how cheaply, but rather how well and how regular as to composition, the coal can be mined for the purpose it is to serve. Our New River coal is always low in ash and low in sulphur, and uniformly so. Our Freeport coal, although higher in ash, is exceedingly uniform, both as to ash and sulphur, notwithstanding the fact that the Twin Freeport seam contains, in the center, a six-inch band of coal and bone, with an eight-inch bone band directly underneath it, and with occasional veins of slate, clay, pyrites and mother coal throughout the seam. During the period mentioned in Mr. Mathesius' paper, our daily analysis of that coal at our works showed an ash content varying from 9.30 to 9.90 per cent, with only three daily exceptions, and these were only slight modifications. In view of the discrepancies between car lots and belt samples shown in the coal diagrams of the paper, I realize that Mr. Mathesius will hesitate to accept our daily analysis as conclusive proof of the uniformity of the coal going to the ovens. Be it said that a similar uniformity exists in analysis of samples for shorter periods. This is due to the levelling effect of a coal storage, held, according to the author, in such odious repute by blast furnace operators. I do not doubt that a greater irregularity exists between each car of a shipment, ready for its journey at the mines, but this coal travels to the Lake and is accumulated in bunkers. From the bunkers it is loaded into boats. Upon arrival at our dock it is again unloaded into bunkers holding an aggregate of 5,000 tons, and from there it is conveyed, by belts running underneath the bunkers, over a bridge spanning the storage field to its temporary abode. The bridge is provided with a belt conveyor and tripper, and the coal can be deposited at any place in the field. Due to the levelling effect of the many transfers in its journey from the source to its destination, the composition of that coal at the ovens is very uniform indeed.

Not all the coal necessary for our coking operations comes from our own mines. A part of it is bought in the open market, and again, it is a privilege to be able to state that those responsible for the purchase of that coal exercise care and judgment; that the price is not the only controlling factor; and that some consideration is given to the man who has to use it and is expected to produce a uniform coke. Such coal is always bought under specifications as to locality and chemical analysis, and I well remember, some years ago, when a contract for Pittsburgh coal over a long period of time was under consideration, that a representative of our company examined and sampled the contractor's mines along the Youghiogheny River, and selected and specified the mines from which the coal was to apply on the contract.

In addition to the changes in methods of accounting and mining suggested by the author of the paper, I contend that great progress towards uniformity can be attained by closer co-operation between the powers that purchase or distribute the coal, and the organizations that have to convert it into coke.

The ordinary designation of "high" and "low" volatile coal is but a poor classification of the characteristics of either class. To ship to one plant together, two coals of dissimilar coking qualities, or of greatly varying chemical composition, under the broad name of, and to be used at the same time as the "high" or the "low" volatile component of the mixture, is not conducive to uniformity. Instead of depending on the coke plant to absorb such inequalities, and by mixing endeavor to make out of such heterogeneous shipments a homogeneous lot, it were far better to keep them separate, either by using them on separate plants, or if required for the same plant, to use them at separate times. The ash and sulphur in the coke might then be higher on one plant than on the other, or if used on the same plant, higher during one period than during another, but they would be uniformly so.

To ship coal to a coke plant, blessed or cursed, according to view, with the facilities or the impediment of a large coal storage, without considering the condition of the coal already or still in stock, is not conducive to uniformity. To ask the coke man to take care of thousands of tons of coal for a rather long period of time and compel him to stock freshly mined coal on top of old coal, or to stock Western coal in close proximity to Eastern coal, or to stock washed coal with dry unwashed coal, is inviting danger of coal fires, with the consequent result of irregularities in coke plant operation, as well as non-uniform products.

If, by closer co-operation, these sources of non-uniformity can be overcome, coke men can, and usually do, further assist in promoting the object so greatly desired.

Referring again to the "odious repute" of a coal storage, I have experienced that the odium can be greatly minimized by taking precautions in judiciously stocking, preventing, as much as possible, the segregation of coarse and fine material, by keeping old and fresh coal separate, by systematic examination of the stock piles and immediate removal of all spots and pockets that are heated up, by using up the coal in the same rotation as it is stocked, and by having the field in such condition that coal can be turned over and aired before serious deterioration has set in. The variations in the coal mixture, compared with those in the components of the mixture, as shown in the coal diagrams, can be reduced by preventing segregation of the pulverized coal in the supply bin, or bins, over the ovens, keeping them always full, so that no pronounced cone can be formed, permitting the coarser particles to roll to the sides of the bins. Another aid towards keeping in the mixture the exact proportion of each component that it is supposed to contain, but most times does not, in spite of regulating gates at the outlet of the bins, I found by providing short skirt boards along and just above the sides of the belts, and by having an adjustable gate across them. The gate is ad-

justed so that the coal, passing underneath, flattens out without accumulating in front of it, and a rectangular section of coal on the belt is the result. If the belts run at the same speed, the weight of coal per foot in the rectangular section on each belt must be of the same proportion as the opening of the regulating gates. Once per day, or as many times as occasion requires, the belts are stopped, and three feet of coal on each belt is weighed, to determine whether the mixture actually consists of the intended percentages of each component. The skirt boards and gates are located just previous to where the coal enters the mixer. I am under the impression that the mixer itself, another feature of uniformity, is a part of but a few existing coke plants.

Of non-uniformity of coke due to irregular heating, I need not speak. The importance, rather the prerequisite, is recognized universally by every coke man, who gives that his prime attention, but the fact should be remembered that a uniform heat demand, which depends on a uniform coal charge, is no less essential for the attainment of the desired end, than is a uniform heat supply.

Mr. Mathesius has handled his subject along general lines. I have referred in my discussion to individual practice because, being a firm believer in the gospel of uniformity preached by Mr. Mathesius, I do not hesitate voicing my conviction that the wisdom and foresight of those who control the elements of uniformity of our raw material are reflected in the uniform performance of our blast furnaces.

The Chairman (Mr. John A. Topping): We will now hear the paper, Selling Practices in the Steel Industry, by Mr. Ernest T. Weir, President, Weirton Steel Company, Weirton, W. Va.

SELLING PRACTICES IN THE STEEL INDUSTRY

ERNEST T. WEIR

President, Weirton Steel Company, Weirton, W. Va.

The subject allotted to me, "Selling Practices in the Steel Industry," is so wide in its possibilities, that I may be excused if I fail in this one paper to cover all of its ramifications.

I would like to say in the beginning that nothing in this paper is intended to suggest, much less to advocate, any collusion in the establishment of prices; I believe in free and legitimate competition and I know of no industry that is more competitive than our own.

Securing a profit from the operation of business is fundamental, because no business can prosper and develop and be a valuable asset to the country at large unless its operation is carried on at a satisfactory profit. This means not only paying to the owners a fair return on their investment, but also providing a surplus for improvement and development. I think this is particularly true of our own industry, which requires such large expenditures for new construction to take care of the increasing demand, and for reconstruction to meet the new developments and improvements that keep the industry up to date, as it were.

To insure a proper profit in our business necessitates efficiency in the manufacturing end (I include in this the purchasing of materials needed, on a competitive basis) and selling our products at a price higher than the total cost including all overhead, interest, depreciation, etc.

I believe I am safe in saying that, with the majority

of the steel companies operating now, there is a general efficiency in the operating and production departments of the business. I believe that as a rule the executives of the companies give constant and detailed attention to this branch. Costs are carefully scrutinized, production fluctuations carefully considered and the keenest competition established between different plants of the same company. As one executive recently said to me, "We are constantly trying to cut our cost of production even to the point of a few cents a ton." I believe this largely comes from the fact that the executives are generally men with a love of production and development. The cost and production figures represent to them the activity of the mills, the furnaces and the mines, etc., the tangible things that thrill their constructive ambitions. To every real manufacturer of steel, there is a certain romance connected with the mills and such as has caused Mr. Schwab to say that he wanted to leave as a heritage miles of flaming stacks. Then, also, there are the constantly changing problems in the manufacturing end, the new requirements, the improvements regularly being made that increase the tonnage, or reduce the cost, or improve the quality. Then there is always before us the tangible, visible thing in the great mills that keep alive the interest and stir the imagination. For these various reasons the executives as a rule, I believe, devote more time and thought and personal interest to the question of manufacturing than they do to the problem of the merchandising of the product of the mills. And when I say problem, I speak advisedly, for I know of no greater one daily confronting us as manufacturers.

I believe in the first place that we executives do not give sufficiently detailed attention to the matter of sales; we put too much pressure on our sales managers to secure business and do not stress sufficiently the necessity of making a profit on every sale.

I find sales managers who point with pride to the fact that their plants are operating either full or beyond the

average percentage of the whole industry and who pass over very lightly the fact that earnings are small or maybe invisible. Their task apparently is finished when the mills are supplied with orders, not profits.

Gentlemen, the time is here when the fundamental reason for the existence of our business—that is, to make a profit—must be considered on every sale, when the executive must himself see that the sales manager shoulders his share of this responsibility and only pats himself on the back when the order book is fat with profitable orders and not simply with orders for tonnage only. I am frank to say I believe that for this lack of constructive policy on the part of our sales people, the executives are to blame. In our anxiety to keep the wheels turning, we hammer the sales manager for orders, not profits. Now I hear you say that you do discuss costs and profits with the sales department, of course we all do, but frankly, is it to the point of where you frequently say, "No, we will not take this business because it will produce no profit, and profit we must have."

We seem to assume most naturally in our industry that when demand drops off and operations decrease that we must immediately reduce our prices and go out and buy business, and that during these depressed periods we are justified in worrying along without profit. I don't believe this is sound business, for when production decreases, costs advance, and lower prices as a rule mean losing prices.

Because we are down to a 50 or 60% basis is no good reason why we should lose money by selling at a low price.

I believe that our business should always make a reasonable and regular profit. Not an exorbitant one in some years and a loss in others; not an average, but a regular profit. When prices are advanced to a point too high, we all know from our experience that they will go just that much too low. None of this is good for any of the interested parties, the manufacturer, his employee,

or the buyer, or the ultimate consumer. What we should strive for is regular earnings and such as our investment and responsibilities demand. Therefore, I say, let the executive take the responsibility of fixing the prices for the sales department and let him fix these prices based on his cost plus a fair and reasonable profit. Do not insist on the sales manager furnishing orders to operate the mills 100% when the general business is on a 70% basis. I believe it is impossible for any concern to perform this miracle without a complete sacrifice of profits. I believe, generally speaking, that our sales people put too much stress on price and do not make enough effort to sell quality and service to the buyer. After all, what does a price mean to that buyer, if you fail to ship his order on time, or if, when he gets it, the quality is bad. All buyers are receptive to talk about your quality and service, but we in the steel industry seem to think that his only interest is price, and naturally Mr. Buyer encourages you in that belief. Our sales people should be educated into a thorough knowledge of the products they are selling, and as their knowledge of this expands, they will find the buyer easier to talk to and more interested in the quality and service. One great trouble is that too many of our sales people know nothing to talk of but price, and that with the astute buyer leads as a rule to cut values.

I think often that we give our salesmen too much jurisdiction in the matter of prices. This may not be so dangerous with the salesman who knows his business through long experience and has some practical knowledge of the products he is selling, but with the general run of salesmen it is a dangerous and unprofitable method. By such laxity we invite the salesmen to be over credulous of the statements of the buyer about the price he can secure, for the salesman wants the order and when all he has to do is to report that he simply met competition and repeat what the buyer told him, he consequently does not have to work overtime to convince the

buyer that his service and quality and price combined justify his receiving the order. Don't let our sales department degenerate into order takers, let us make them salesmen who sell *quality, service* and who secure a profit on the sale. The only man who is worthy of the name, salesman, is the one that always has this in mind and puts it over.

Some executives say they do not have time to attend closely to the facts necessary to oversee and control their sales department. I know by experience this is not correct, because the President of one of our greatest corporations finds time to do this and do it regularly. I believe that the executive of every company should have the time and system to know what both his sales and operating departments are doing. After all, his is the final responsibility and he accepts this when he takes the job; and if he does it right he must devise ways and means of knowing always what is going on and then of being the court of decision at all times.

I believe our sales people are too prone to believe unauthenticated reports about prices and terms, and in the haste of the moment and in the pride of their company's ability to meet the lower price, fall for false statements. Stop, look and listen, is a good policy at all times.

Another matter that is of great importance and should have the serious consideration of the entire industry is the laxity with which our sales contracts are treated. It is a well known fact now that contracts covering the sale of our finished materials are really nothing but options that the buyer can exercise or not as he sees fit; whereas they are a definite binding obligation on our part to supply a fixed tonnage at a fixed price if the buyer so demands. While in our contracts there is nothing that guarantees prices against decline, nor relieves the buyer from the necessity of taking his purchased tonnage, yet it has become an implied fact that, if the price of the commodity declines during the term of the contract, we immediately reduce the price and the buyer, as a rule, will

refuse to specify the tonnage unless we meet this condition.

I have in mind particularly one very large buyer of a standard commodity who contracts with four or five different manufacturers always for more than he can possibly use: if the market strengthens and advances in price, he loads himself up; on the other hand, if there is no advance or prices decline, he takes out only what he wants and then only when the price has been reduced to meet the lowest quotation. This man has absolutely no regard for the sanctity of his obligation and is, I am sorry to say, representative of too many buyers of steel products.

Under present methods of sale, the buyer is always pressing for lower prices, whereas such would not be the case if he had to carry out his contracts at the contract price.

For this condition, we manufacturers are alone responsible and it is causing the steel industry many millions of dollars in losses. Take, as an example, the way in which it affects the tinplate manufacturer. In November he sells his product for delivery up to July 1st of the following year, thus obligating himself for practically eight months ahead. If he covers himself on his tin requirements in order to make sure that under all conditions he can supply the material for which he is obligated and within a few months the price of tinplate declines through weakness of the pig tin market, he must reduce his price and he is left high and dry with an accumulation of high priced tin, which he purchased solely to protect deliveries of the buyer against an actual bona fide contract, and yet he is the one who has to finally take the loss. If when selling his product in November he does not cover himself on his tin requirements against his sales and the price of tin advances ten cents a pound, which it frequently does, and consequently strengthens up the tinplate market, then he has to buy the higher priced tin and take his loss, because of course he cannot

ask the buyer to pay him more money. In other words, we live up to our obligations both in tonnage and price, but it is a one-sided arrangement and the buyer fails to live up to his.

It is a further fact that on any of the various materials which we all purchase we have no such protection as we afford to our buyers, but religiously live up to our obligations at the price at which we purchased or contracted.

One of the worst things about this failure to observe the sanctity of the signed contract is that it unquestionably tends to weaken the fundamental morality of our business. There is one great exception to this condition, and that is among the larger oil companies: they still religiously adhere to the policy of fulfilling their contract obligations, and I yet have to hear of the first case in which they ask for reduction in price, no matter where the market goes. They purchase from you, sign the contract, take the material out and pay the contract price. If they can do it, why can't other buyers?

I would like to recommend that our sales departments be carefully advised as to the real facts surrounding the issuing of earning statements of the larger companies, when such statements are made public.

For some reason the practice is to give out gross earnings; that is, earnings before deduction for interest, depreciation, depletion and so forth. The public generally fails to analyze these statements, consequently the gross figure becomes fixed in their minds as the one that represents the earnings available for dividends and development; consequently they have an exaggerated idea of the earnings of the steel industry.

One of the largest customers of our company recently made the statement to one of our district sales managers that, based on the Steel Corporation's last statement, the profits of the steel industry were entirely too great, and he took the gross figures for last year as the basis for his statements; this was reported to our general office, and we sent out a complete analysis of the figures showing

the net earnings per ton, which satisfied him after analysis that the earnings per ton were nothing more than normal.

The steel industry and its situation is always of such great interest to the buying public that I think it is always important that they get not only the correct figures, but the correct impression; and for this reason it has seemed to me that it would be better if, when statements of earnings are made, the net figures be the ones that are emphasized and not the gross earnings. If for some reason this cannot be done, then I believe the sales department should be instructed in the detailed analysis of the report, so that the net profit can be worked down to the amount per ton of ingots produced.

I cannot end my remarks without referring briefly to one of our very serious problems in some of the branches of our industry, and that is the matter of disposing of our off-grade product; by this I mean Seconds and other accumulations in sheets, strip steel, tinplate, pig iron, semi-finished steel, etc. Hardly a line but has its off-grade product problem today.

The tonnage produced in these off-grades is so considerable as to have become an important factor in the profit question. For instance, in tinplate it is estimated that between four and five million boxes per annum, or approximately 10 to 12½% of the total production, is stock accumulation and sold from the stock sheets at varying prices, but always materially under the price of prime product.

We are all familiar with the importance of the production of seconds and off-grade material in mills manufacturing pickled finished sheets for various purposes. The accumulation at times becomes so great as to be very burdensome, and then the material is marketed and simply dumped at prices even below that of one-pass sheets and the consequent loss is very heavy. The same condition applies to every line that produces off-grade products.

In the earlier days, when this question was not so

serious and the production of these off-grades smaller in proportion, they were not given much consideration by the sales department and as a rule were turned over to middlemen at any price that could be secured. I believe that as the tonnage has increased the attitude of the sales department has not changed, and the tendency is still to dump these accumulations in order to get rid of them and not to make the proper effort to merchandise them on a basis that would give a fair return.

I have heard it frequently said in connection with tinplate, sheets and strips, "Oh, well, this is simply stock accumulation and we had better get rid of it in order to clean the material up."

The term "stock accumulation," I believe, has become a misnomer, because all of this tonnage is actual production and should be so considered; and a proper effort made to merchandise it, not dump it.

I believe that this is a matter that the executives and sales managers could profitably give close attention to, for the purpose of, in the first place, reducing the production of these accumulations, and a careful survey should be carried on as to why off-grades are produced, and then followed up to keep the production down to a minimum figure.

I have recently come to the conclusion, after having this survey made in our mills, that in many cases we could profitably produce more scrap rather than this off-grade material. I think there are two reasons for this; in the first place, very frequently we send this material through the mill and all its processes and then sell it at tremendous loss, whereas we would have been better off to have simply scrapped it after the original process. In the second place, these large accumulations have a very direct effect on the price that we can secure for our prime product. Large tonnages of off-grade materials hanging over the market invariably weaken the buyer's ideas of price, and when our sales department offers to him this material at prices dollars a ton under the prime

price, he immediately comes to the conclusion that the price for the primes is too high and proceeds to try to beat it down.

I consider this question of trying to prevent the production of off-grade material as of great importance and that it offers a possibility of large improvement. I believe that through special investigation, either carried on by individual companies or by branches of the industry, new uses should be developed for these off-grade products, and that our sales department should be educated into trying to handle this material on a scientific basis, with the idea of producing a profit out of it rather than the question of simply dumping the material in order to get it cleaned off the sheet.

The details of how these things are to be accomplished, of course, are not for me to suggest now, but are up to the different organizations, but much good can be accomplished and much profit can be made by the reduction in production and then proper merchandising, with the idea of securing a profit just the same as on prime product rather than with the idea of taking the easiest course.

Another thing, I believe that as uses are found for these products it also may be developed that there is a seasonable consumption; and that it pays at times to carry the stock into the period when there is the best demand, rather than to try to force it on the market when there is no proper consumption going on.

This all, of course, becomes a part of the whole careful study of off-grade materials and I offer this as a matter of great importance for the consideration of the executives and the heads of the sales departments.

In conclusion, the production can be reduced, new uses developed and better prices secured, if analytical care is given to this very important subject.

THE CHAIRMAN (Mr. John A. Topping): Gentlemen, before adjournment I want to announce that the Directors of the Institute will hold a meeting of the Board immediately after adjournment.

This session will be reconvened at 2:15 and, as we have a very interesting lot of papers, I hope you will give full attendance.

A recess was then taken until 2:15 P. M.

Members assembled in the East Ballroom at the appointed time, Mr. William A. Rogers, a Director of the Institute, in the chair.

THE CHAIRMAN (Mr. W. A. Rogers): The first paper this afternoon is The Manufacture of Steel for Ordnance Purposes, by Commander J. B. Rhodes, United States Navy Yard, Washington, D. C., to be read by Mr. William J. Priestley.

Mr. Priestley, will you be good enough to report to Commander Rhodes that we regret very much that he could not be present to deliver his own paper, but as he could not, that he sent a very capable representative?

MR. PRIESTLEY: I will be very glad to do that.

THE MANUFACTURE OF STEEL FOR ORDNANCE PURPOSES

Commander J. B. Rhodes, U. S. N.
United States Navy Yard, Washington, D. C.

The purpose of these notes is to secure the greatest strength and reliability in steels used for ordnance. In the manufacture of guns and ordnance parts subject to great and sudden stresses, there has been developed a steel which requires certain qualities and methods of manufacture, not necessary in ordinary commercial steels. In a "Man-of-War," it is imperative to get the greatest strength in the limited weights that can be assigned to the various parts. Year after year the weights have been reduced as stronger materials have been made available. There is at present a call for steel of similar characteristics for small forgings in automobiles. For want of a better name, we shall call this material "Ordnance Steel."

The greatest steps in improving ordnance steels to date have been in the heat treatment, after the metal has been melted and forged. In fact, since the introduction of physical testing and metallographic examination, it has been possible so to standardize the thermal treatment that there is no longer much mystery in heat treatment. A student can find sufficient material in text books to guide him, so that, in a short time, he can successfully treat the steel that is furnished him.

In the manufacture of steel for ingots, we try to produce steel that will give us ingots that are free from cracks, flaws, and as nearly as possible free from microscopic inclusions and occluded gases. The melting prac-

tice needed in the production of ordnance steel has not been described as fully as has the heat treatment practice and considerable obscurity remains.

The chemical reactions which take place from the time the ore is heated in the blast furnace until the melted steel leaves the furnace have been described in books on metallurgy. A great deal has been omitted and very little is written covering the temperature factors, the care needed in pouring and the variables introduced by differences in molds. The details of the reactions that can be found in text books are omitted here, but it is recommended that they be gone over again after considering the points made in these notes. It is difficult to understand the chemical formulæ unless one has grown accustomed to them by daily contact. Only chemists really understand words like "valency, nascent, molecule, atom, etc." Such words, after all, are visualized, if at all, only after a great deal of laboratory work, but they are convenient and shorten our paragraphs. It may help to think of silica as sand and silica brick and to use SiO_2 as an easy way of writing it. In the same way iron oxide is the rust on iron, or the scale on forgings and on annealed castings, or it is hematite ore that is loose and powdery, and written Fe_2O_3; or magnetite ore that may be hard and rocky and is written Fe_3O_4. Iron oxide is formed by the combination of the oxygen of the air attacking iron and forming rust or in the furnace, forming scale.

In the blast furnace the iron oxide goes in with the charge and the carbon of the coke collects oxygen from the ore and reduces it. At the same time the carbon unites with the iron to give pig iron. The ores carry silica, manganese, etc., and, with lime added, there is a slag which will not eat the walls of the blast furnace. But in a steel furnace the heating of steel scrap will permit the formation of iron oxide and the oxide will attack the furnace walls. Iron oxide, when near its melting point, will combine with anything that will lower

the melting point of the mixture. It takes carbon; but if there is not enough carbon present and there is a sand bottom, it will combine with this and form what we call slag. If the bottom is magnesite, and we use limestone in the charge, the slag will be a lime-iron oxide combination. In an acid furnace, iron oxide will take the silicon, manganese, chrome, etc., before it takes carbon, but these are present in such small quantities that we protect our furnace walls and bottom with the carbon of the pig iron, or perhaps some anthracite or petroleum coke.

The oxidation of the silicon in the acid converter, and the oxidation of phosphorus in the basic converter, occur before the carbon blow commences. The heat produced by the first blow is necessary in order to attain the critical temperature at which the carbon and oxygen will combine. The carbon of the bath in an open-hearth or electric furnace will not unite with the oxygen until a critical temperature is reached, so that our slag begins to form with the attack of the iron oxide on the silicon, manganese, lime, etc., available. The slag protects the bath from oxidation by the flame. The shorter the time that the flame has to work on the metal before the slag is formed, the less the oxidation that will take place. The electric furnace has an arc to furnish heat and it does not have a flame that will oxidize the slag, as does the flame in the open-hearth. Slag is lighter than the metal and floats on the surface.

To reduce the amount of carbon in the bath, we depend on iron oxide which we add in the form of ore or scale, the amount depending upon the carbon after the melt down. But this iron oxide would be highly objectionable in the finished steel, so we prohibit additions of ore when within two hours of the tap. Not all of the oxide will combine with the carbon; the last traces of oxygen remain until we add another deoxidizer, such as silicon, manganese, aluminum, etc. The failure of the carbon to deoxidize the metal may be ascribed to the fact that

there are parts of the bath near the walls and bottom, that are below the critical temperature for the reaction. This is indicated by the activity we get when we rabble. The failure to eliminate the last traces of iron oxide with carbon is not explained satisfactorily as yet and it is held by some that oxygen remains even in cast iron.

Iron oxide must be reduced to the minimum to make ordnance steel. Phosphorus and sulphur must be reduced to .05 and, if possible, eliminated. In the electric furnace we can easily keep below .025 but not in the acid open-hearth. Very low phosphorus may cause difficulty in machining, but the ill effects of sulphur and phosphorus in excess of .05 are well known and it is suspected that the reason will be found when we consider that the oxides of these two, which form during freezing, do not collect and form inclusions as well defined as the silicon and manganese inclusions. Phosphorus will be held by a lime slag while metal is full of oxide and not too hot. To eliminate phosphorus in a basic electric furnace, we must slag off or the phosphorus will go back into the bath during the finishing period, when we are removing iron oxide and sulphur and obtaining hot steel under a white slag.

It is known that besides carbon, other deoxidizers, chiefly silicon, manganese and aluminum, will remove oxygen from steel and will reduce the amount of gas formed by the reaction between carbon and oxygen on solidification. These elements form non-gaseous products and it is apparent that they combine with oxygen in the steel and are effective at a time and at temperatures when carbon is not effective. All these elements are more effective in a nascent state, that is, just after being freed from one combination they are more susceptible to assuming another. It seems fair to say that, if we are reducing silicon or manganese from a slag into the bath, we have very little iron oxide in the steel, for the elements are entering the steel in a nascent state, and would be oxidized if there were any oxide present. So

we make our best steel in the electric furnace, where the manganese from the slag is reduced into the steel, and next best in the acid open-hearth, where silicon is reduced into the steel.

The temperatures of the bath and the furnace have to be considered when we deal with reactions. With a heat barely melted or with pig iron just after melting, there will be no action from the addition of iron oxide, but later, as heat is applied, the mixture will boil violently. So the carbon and oxygen do not combine until a critical temperature and superheat are brought in. On solidifying we find that there is a temperature in cooling where the carbon oxygen combination takes place and the iron makes a last effort to get rid of the oxygen. This is what causes blowholes and puffs at the last minute in solidifying. It seems that the metal must be hotter going up and colder coming down—the elements hold together and resist change. This seems to be a law of nature; to hold present conditions and to get change by violent methods.

Temperature affects the elimination of phosphorus in a basic furnace. If the metal gets too hot, before the phosphorus is taken up by the slag, we will have no more elimination of the phosphorus. In fact, the phosphorus will go back into the metal, if the bath is quieted and deoxidized. In the basic open-hearth, when we are eliminating the phosphorus of the charge, we tap the heat while still wild and deoxidize in the ladle with ferroalloys. In the basic electric furnace, we take off the slag through the spout and then go ahead and deoxidize and refine the heat. Whatever phosphorus gets into the slag as P_2O_5 will be held as a calcium phosphate until we put silicon or manganese into the metal or carbon on the slag. These will reduce the phosphates and put phosphorus into the metal.

The temperature of the bath in any furnace cannot be accurately measured. A solidification test (time in seconds for a spoonful of metal to cover with scum) is

a good guide to temperature, in a relative sense, for comparison of heats. The optical pyrometer gives assistance in the same way and gives an approximation to the true temperature. As a result of the inadequacy of temperature measuring devices, it is necessary for melters to make rules of their own for the furnace they are using, taking into consideration the variations in color of the slag, walls and roof, in fact, to observe anything that may indicate the temperature in a relative sense. Just as one learns to judge carbon from fracture, it becomes possible to watch the stream, as it runs from the furnace, and judge the temperature so as to make a correct decision as to the length of time one dares to hold the steel in the ladle.

With the slag as hot as the furnace will stand, the slag in an acid open-hearth furnace will get thick. The reason for this is that the iron oxide of the slag is taken into the bath, in which it is soluble, and reduced by the carbon of the bath, leaving a larger percentage of SiO_2 in the slag. The addition of fluorspar and lime at this time will furnish an oxide to replace the iron oxide and make the slag thin. The bath near the walls and bottom of the furnace is colder than the part of the bath closer to the flame and it is possible that one may be below the critical temperature for carbon reaction in one part and not in the other. As a result, it is important to stir and rabble the bath so as to bring the temperature up to the critical point throughout. In fact, to get the best results and to get rid of the iron oxide to the limit, we must superheat the hottest part of the bath nearest the flame. With this condition of superheat and a slag with the iron oxide reduced to a point where we have to add some thinning agent, we may expect the bath to pick up silicon from the silica. It is suspected that the iron of the bath is converted to iron oxide by the oxygen of the silica and that the silicon which is so freed goes into the metal. Iron takes only half the oxygen that silicon requires so that two atoms of iron are oxidized to free one of silicon

and the percentage of silica in the slag tends to rise at this time.

This paper is largely devoted to the subject of making slags and it will be supplemented by some chemical results that have been obtained. The chemical composition of slags has been described in text books, but the slags described below were taken from large electric furnaces and in all cases the physical values on tangential test were superior to 100,000-70,000-20-45. When it is considered that these were transverse tests of nickel steel, it seems fair to say that the elimination of sulphur and phosphorus as shown by the analyses (under .025) and the elimination of iron oxide as indicated by the small amount in the slag and the low manganese in the slag, has produced the best ordnance steel. The slag should not contain more than 1% of FeO nor more than 0.50 MnO and not more than 1.25% FeO plus MnO.

ANALYSES OF SLAGS IN ELECTRIC FURNACES MAKING ORDNANCE STEELS

SiO_2	FeO	Al_2O_3	MnO	CaO	MgO	P	S
19.54	.58	4.27	.06	62.86	7.38	.004	.687
18.38	.83	3.15	.21	62.22	8.34	.005	.444
24.01	.90	3.16	.34	50.74	15.55	.001	.308
19.20	.75	4.39	.52	61.78	12.77	.044	.360
19.54	.54	4.27	.06	62.88	7.38	.004	.360
18.38	.83	3.15	.21	62.22	8.34	.005	.444
.....	.64	....	.05	63.38	.....	....	....
.....	.85	....	.15	55.88	.....	....	....
.....	.61	....	.10	59.40	.....	....	....
.....	.81	....	.10	56.76	.....	....	....
.....	.57	....	.12	54.88	.....	....	....
.....	.77	....	.12	56.56	.....	....	....
.....	.53	....	.04	62.26	.....	....	....
.....	.43	.....	.26	59.92	.....	....	....
.....	.65	....	.06	60.16	.....	....	....
.....	.65	....	.05	52.36	.....	....	....

If the slag is properly made, the steel will almost take care of itself. The making of proper slags depends a great deal upon the tool that we use. The electric furnace is the best tool, for we can hold the steel in the furnace and alter the slag by increasing the heat or mak-

ing additions to the slag or furnace, whereas in a furnace where the slag is exposed to a flame, the action of the flame will affect the slag and metal. We cannot shut off the flame for very long because the heat will become too cold to tap. Any change in the slag means a change in the steel; in a slag of lime and iron oxide there is no real stability until the iron oxide is replaced by calcium carbide, for the amount of iron oxide in the slag will vary as the oxide in the bath varies. Any stability is temporary and depends upon the relation of the bath to the slag and in an open-hearth furnace the flame continually disturbs the balance.

The electric furnace provides a neutral atmosphere or even a reducing atmosphere on account of the carbon of the electrode. It is quite easy to reduce manganese, silicon, molybdenum, chromium or other alloy into the bath due to the reducing action. It is more striking to add a new element, as has been done with calcium molybdate, than it would be to increase the silicon or manganese. It is more certain that we are reducing molybdenum into the steel than that we are adding iron as we reduce iron oxide, that is to say, the evidence is more tangible. To demonstrate the possibility of reducing an alloy into the steel it is recommended that sand be added to the slag and reduced to bring up the silicon of the metal; this can be tried out for demonstration to melters and helpers after the furnace bottom has lived its life. This reducing of silicon into the metal will show the intimate relation between the slag and the metal and, until this relation is fully realized, in all its phases, the operators on the furnace will not get the best results. Observation of slags and study of physical tests make it possible to say that the best way to get steel free from iron oxide, and the inclusions it produces, is to get the iron oxide out of the slag. In whatever furnace we use, the steel is not in proper condition until the iron oxide of the slag has been reduced to the lowest figure that we can reach with safety.

In an acid open-hearth furnace, as stated before, the silica (SiO_2) of the acid slag will take up iron (Fe) from the bath and reduce silicon into the steel; this maintains the percentage of iron oxide plus manganese oxide of the slag at about 35%, measured in terms of metallic iron and manganese. So we never get acid slag entirely free from iron oxide, but when we are reducing silicon into the metal, as shown by the increased silicon of the metal, we can be confident that there is not a harmful amount of iron oxide remaining in the bath. The addition of lime and fluorspar to thick and viscous acid slags frees iron oxide from the slag to reduce the carbon of the bath and reduces the amount of iron oxide in the slag. Proper acid open-hearth slag will be green in color, due to manganese oxide, vitreous and free from blowholes in samples taken of the slag. If a slag is of proper color and consistency, but too thick, it is possible that the metal may be exposed to the oxidizing action of the flame and so oxidized as to offset the good slag. Even with the best of acid slags there is not as much reason to feel that the iron oxide has been eliminated as in the electric furnace, for the slag will continue to react with the bath as the temperature changes. It is not only necessary to have a proper green slag, but the metal must be made as hot as possible so as to get the maximum reduction of iron oxide by carbon. This heat is distributed throughout the bath by rabbling, so as to get all the iron oxide in solution in the bath up to the critical temperature, for the carbon-oxygen reaction to take place. Even after this has been done and the metal lies quietly in the test mold, the addition of silicon to the bath to bring the content up to about .25, followed by the addition of manganese to bring the manganese to about .65, will still further reduce the iron oxide and will furnish deoxidizers to prevent the formation of gas on solidifying, for oxygen has been picked up by the molten stream, from the furnace to the ladle and from the ladle into the mold.

Some steel makers state that the elimination of oxide from steel is not necessary. This is probably based on the fact that they have produced steel, which has been used in guns, which they know has contained oxide. The fact that steel containing iron oxide and blowholes, but no inclusions, is superior for tin plate, for example, does not mean that similar steels can be used for ordnance, for the accumulation of the inclusions into globules of relatively large size is safer than the distribution of such oxide between the grains. With steel so thoroughly killed as to give off no gas, we get material so dense that there is a risk of cracking on solidification. This must be taken care of by teeming at a slow rate and by allowing the metal to cool to a point where there will be a small skull in the ladle and barely be heat enough to run through the nozzle without streamers. Besides the objectionable iron oxide, we must eliminate other factors which can cause defects in the transverse tests which are taken for ordnance steels. The rate at which the mold is filled must be made as slow as possible; the temperature of pouring must be kept down. These two factors, when properly controlled, give a characteristic appearance of the top of the metal in the mold, which has been described as a breaking creamy appearance. The thickness of the mold must be great enough to give the least possible time for the reactions to take place. Thick mold walls with a ratio of 3 to 1 will chill the metal and give the maximum practicable speed for solidification. In one experiment with a steel containing 2% of manganese it was found that an extraordinary, heavy chill and the pouring of the metal through an iron runner of the mold gave a most excellent material. The difference between the results in this mold and the results obtained in an ordinary mold with the same composition has been assigned to the rapid chilling of the metal. In ordinary molds 2% manganese in metal will make metal extremely brittle, whereas with the mold described the test bar bent to 180° around a one-inch radius.

In spite of our efforts to remove oxygen from steel and to obtain inactive slags, there are further reactions to be reckoned with. Even if the steel in the furnace has reached the limit as regards cessation of reactions, yet the agitation of the metal from the furnace to the ladle and from the ladle to the mold, the change in the temperature that occurs after the heating has ceased and the exposure of the metal to the oxygen of the air, will so change conditions as to permit the occurrence of reactions, in the solution of iron, oxygen, carbon, silicon, manganese, sulphur, phosphorus and alloys. Such reactions, affecting the intergranular structure of the metal, continue to occur until the metal has solidified and the grains have formed. These reactions produce gas or solid nonmetallic impurities, which cannot escape during solidification, evidence of which is found under the microscope in the form of gas holes or inclusions. The formation of gas or inclusions is less pronounced in metal which remains in the mold for the shortest possible time in the liquid state. This quick chill is obtained by (1) slow pouring, using small nozzles, (2) holding metal in furnace and in ladle, (3) use of ingot mold with an area of mold about three times as large as the area of the metal which it contains.

The use of heavy chill molds to prevent the formation of gas holes has led to the abandonment of the advantages of bottom pouring. It is recognized that bottom poured ingots have excellent surface and that they forge well, but this is partly offset by the risk of carrying into the mold the inclusions resulting from the reaction between the runner brick and the metal and even the scourings from the brick. In using the heavy chill molds and obtaining the quick chill, it has been found that the use of a pouring box or tun dish gives more uniform rate of pouring and a better average appearance of the bottom of the ingot. There is a risk of carrying inclusions into the ingot, just as with bottom pouring, but it is believed

that material carried in from a pouring box will have more chance to get out of the metal than that resulting from bottom pouring. The pouring box is only a safeguard against splashing on the bottom and high rate of pouring and where conditions are such that the risk of poor surface and excessive pouring speed are negligible, the pouring box is bad to the extent of the scouring of the brick from the two nozzles and the increased exposure to the oxygen of the air.

The quality of a heat of ordnance steel is the result of a large number of variables. It is believed that the variables are important in about the following order: (1) slag composition, (2) pouring temperatures, (3) rate of pouring, (4) size and condition of nozzles, (5) time held in furnace and ladle, (6) kind of charge into the furnace, (7) temperature of ingot when stripped, (8) temperature of ingot when heated for forging. These variables are recorded for each heat and made available for analysis and comparison with the history of the piece until it has been subjected to physical test. Study of records showing these variables has resulted in "Shop Practice Instructions." These shop practice instructions are believed to be necessary in order to reduce the number of variables. All the points given in the shop practice instructions have been proved in practice and it is believed that steels made under conditions where these points are not attended to will only by rare good luck and excellent practice in all other variables, be able to meet the physical tests as specified for ordnance steels. It is hoped that discussion of these points may lead to betterments and that additional evidence as regards the points about which there exists a difference of opinion may be forthcoming. Real evidence as to a number of heats made with box pouring and a number without and the percentage of rejection under each method is what is needed and not arguments in support of one's own practice.

Shop Practice Instructions

It is known that high grade ordnance steels are produced when certain practices are followed in the melting department and that variations in these practices may cause failure of the material successfully to pass tests now required, notwithstanding any efforts made in forging or heat treating to correct the defects resulting from poor melting practice.

A record will be kept showing how far these practices have been effectively carried out for each heat of steel.

The following practices will be observed in the handling of the melts:

(a) Melting: In acid steel, reduction of carbon in the bath shall be accomplished at least two hours before tapping, in order to allow ample time to condition the slag and obtain the necessary temperature conditions for effecting refinement. The refining operation can be facilitated by adding silicon to the slag and ferro-alloys to the steel, but such practice is not as desirable as accomplishing the desired refinement through temperature control and slag control.

(b) Slag: In basic electric steel, the sum of iron and manganese oxides expressed in terms of metallic iron and manganese, shall not exceed 1.25%. In acid open-hearth steel, the sum of iron and manganese oxides expressed in terms of metallic iron and manganese shall not exceed 35%. In the basic electric slag, this condition will be met, when a slag is produced which gives off strong acetylene fumes and disintegrates into a pure white powder. In acid slag, it is met, when the slag is light green in color, and solid and free from blowholes.

(c) Composition: The steel shall be finished in the furnace to the composition specified on the melt orders and no additions for correcting the composition of the steel shall be made in the ladle. The use of aluminum in the ladle is not forbidden.

(d) Teeming: The teeming of ingots shall be such as to cause the most rapid transformation from the molten to the solid state. Metal shall be held in the furnace and in the ladle for a sufficient time to obtain the lowest temperature consistent with successful teeming. The rate of pour shall be kept as slow as is consistent with clean surfaces. Unless specifically authorized, all heats shall be box poured, using the smallest nozzle in the box which practice has shown to be usable.

(e) Stripping of Ingots: Stripping shall be accomplished at temperatures not below 1600° F., ingots to be immediately transferred to the forge shop whenever practicable. When delays in transportation to the forge shop are unavoidable, ingots shall be buried in sand or ashes so as to retain all the heat possible.

The Chairman (Mr. W. A. Rogers): The first discussion of Commander Rhodes' paper is by Mr. R. F. Flintermann, President of the Michigan Steel Casting Company, Detroit, Mich.

Discussion by R. F. Flintermann

President, Michigan Steel Casting Company, Detroit, Mich.

Taking a general view of Commander Rhodes' very able presentation of his subject, there appears to my mind at least one outstanding feature, namely the emphasis placed upon the necessity, in any metallurgical process, of constant painstaking, tireless vigilance during the entire process. This means from charging to solidified ingot, if the desired quality of finished product is to be attained.

In his list of "variables" we find placed as first and most important, the matter of slag composition. This unquestionably is true. I may be pardoned, therefore, if in this discussion I limit myself to slag composition and melting operation.

In a typical acid open-hearth heat, the reactions dur-

ing the oxidation period are pretty clear and well understood.

As we reach the deoxidation period, metallurgists do not agree entirely on the exact reaction at this point. Commander Rhodes inclines to the theory that the Fe of the bath reacts with silica in the slag, forming ferrous oxide and silicon.

You may recall Mr. DeMaré's paper on "The Acid Open-Hearth Process" presented at the May Meeting of The American Iron and Steel Institute in 1920. Mr. DeMaré's explanation is that the carbon of the bath reacts with both SiO_2 and MnO in the slag, producing nascent Si and Mn, respectively, which in turn enter the bath. If any iron oxide is present in bath, the nascent silicon and manganese deoxidize the iron oxide and in turn again enter the slag, thus completing the cycle.

In the discussion following this paper Mr. S. S. Ball quoted authority which offered the opinion that Fe rather than carbon acts to reduce silicon from the slag.

There seems ample authority for both views as far as the acid open-hearth process is concerned. In the case of the electric furnace process, either basic or acid, where carbon or carbonaceous material is added to the slag, I incline to the belief that the added carbon is the active agent, reducing nascent silicon and manganese from the slag and such nascent elements performing their cleansing actions on the bath.

In any case, the desired goal is to have deoxidation carried to a point where nascent silicon or manganese no longer find work to do in the bath and remain in the metal. And this point is reached, as Commander Rhodes points out, simultaneously with a slag condition, which in case of the basic electric process shows a total of iron and manganese oxides of 1.25 per cent.

I wish to make a brief historical reference which bears on this point. I had occasion recently to look up some matters in connection with the early development of the electric furnace for steel production.

In 1906 Prof. Eichhoff of Charlottenburg, in a paper entitled, "Ueber die Fortshritte in der Elektrostahl Darstellung" reviewed the progress of electric steel making. It is rather a long paper and I want to dwell on just one point.

Prof. Eichhoff brought out the fact that, because of temperature control and the high heat obtained, steel could be oxidized to a point where phosphorus and sulphur could be eliminated to a minimum not obtainable by other metallurgical processes. They dared to bring about this super-oxidation because they now possessed means to make necessary correction through a new deoxidizing process, namely, by means of carbon or carbonaceous matter acting through the slag. This slag could be made practically free from oxides and therefore a steel would be produced which would be freer of impurities than by any previous method.

It is interesting to note that so early in the development of electric furnaces, metallurgists sensed so correctly the value of the electric furnace and the new means at hand for obtaining greater purity of steel.

In our own practice in the manufacture of small steel castings by the acid electric furnace, steel is refined through the slag by means of carbon. There is, however, this difference. Because of the high temperature which we must obtain in order to pour small castings of thin section, the work of refining must be done in a comparatively short time. The entire melting and refining operation, starting from cold scrap, takes about one and one-half hours. The deoxidation must be completed and necessary high temperature must be attained before the slag becomes too copious and too stiff.

That this deoxidation is thoroughly done is attested by the fact that we add little or no ferro-silicon and build up our silicon in the bath to the desired content of .35 per cent. Further than that, we obtain an elongation on raw unannealed test bars of 33 to 35 per cent on steel with carbon at .25, which surely would not be possible if any

appreciable amount of oxides were present in the steel. Such ductility is remarkable when you bear in mind that in our case the time element is lacking, which plays such an important part in the large units of acid open-hearth furnaces for ingot production.

THE CHAIRMAN (Mr. W. A. Rogers): The second gentleman discussing Commander Rhodes' paper is Mr. John A. Mathews, Vice-President, Crucible Steel Company of America, New York, N. Y.

Discussion by JOHN A. MATHEWS

Vice-President, Crucible Steel Company of America, New York, N. Y.

We must look to the melting department for the basis of quality steel production. Whatever sins of omission or commission occur there cannot be atoned for by any subsequent operations in hammering, rolling, annealing or inspection. They may, however, be obscured to some extent but will probably crop out later in the hands of the ultimate user. In no commercial application of steel is it more undesirable that the unexpected happen than in the production of ordnance. The Institute is under great obligation to Commander Rhodes for again calling our attention to the details of melting practice and the reactions occurring in melting furnaces of various types. The melting of steel is as truly a chemical industry as is the manufacture of coal tar dyes. The reactions occurring are, however, much less understood by melters and even by the chemists in the steel works laboratories.

A generation ago metallurgy was taught largely as a descriptive science. It was not based upon a thorough knowledge of physico-chemical reactions involved in smelting. While the tendency has been to recognize the physico-chemical foundation of metallurgy in more recent years, yet there are only a handful of men in this country (and they are not all professors either) who think metallurgy in terms of physical chemistry. I have recently

heard young graduates of our leading metallurgical schools complain that their course had been deficient in this regard and they feel its need as soon as they begin to apply their knowledge to practical problems in industry. Only recently I heard a gentleman discussing the enameling qualities of cast irons. He stated that castings of approximately the same composition but made from different pig irons did not behave in the same way Quite recently a leading metallurgist from a drop forge plant stated that during the course of a year in which he was buying steel to one definite chemical specification and for the manufacture of a definite part, he found it necessary to vary his drawing temperatures by some 200 degrees with different heats of steel to produce the desired physical properties in material that was supposed to be commercially identical. Similarly, makers of cold rolled and tempered wire products find it necessary to vary the drawing temperatures of hardened wire when using different heats of steel to the same general specification.

It is not only true as regards steels of the same analysis but made by different processes, such as the acid or basic open-hearth, or basic open-hearth and basic electric furnaces, or between crucible and electric steel, but it is also true of heats made by the same process and by the same manufacturer and from approximately the same type of raw materials. These differences can only arise, in my judgment, from the factors entering into the melting process itself. It has been suggested by a prominent British metallurgist that the relation between a longitudinal and transverse impact test might be used as a criterion for judging the quality of steels. The nearer the two tests approach each other the better the steel will be assumed to be. In testing out this suggestion, however, we find that it is not readily applicable. The ratio will vary greatly in the same heat of steel, depending upon the size into which the steel has been put by rolling or forging. For instance, the ratio between tests made on a

6″ round and a 5″x1″ flat section will be quite different. For heat treated material of high tensile character, it will be found that the nearest approach to agreement between the longitudinal and transverse tests will be found after a drawing temperature of approximately 600° F.

As the speaker pointed out at this Institute in the discussion of chrome molybdenum steels a few years ago, there seems to be a definite minimum point of shock brittleness occurring at approximately 600° F. drawing temperature. This was found to be true not only of chrome molybdenum steels but also in the case of a varied series of chrome nickel steels made by the acid and basic open-hearth processes and by the electric process. The resistance to shock was less at a 600° draw than it was at 400° and in some cases less than at no draw at all. From the point of minimum shock resistance the longitudinal-transverse ratio changes progressively with higher draws and, strange to say, an agreement between tests in the two directions is less with ascending drawing temperatures, which should and do produce increased toughness in both longitudinal and transverse directions. If the merit of this proposed test lies in its ability to pick out dirty steel full of inclusions, then we should expect that the effect of such inclusions should be greater when the temper had been drawn to a low degree or not at all. To illustrate how widely this ratio may vary, it might be stated that in an electric chrome nickel steel, drawn at 600° F., the transverse test was 90% as good as the longitudinal test, while after a drawing temperature of 1000° F. it was only 36% as good. In a similar steel of acid manufacture, and almost identical analysis, the ratio after 600° drawing was 67% while at 800° it was only 24%, yet in both cases the toughness of the material had been increased both longitudinally and transversely at the higher drawing temperature.

In my judgment there is no more promising field in metallurgy than in the study of the reactions of melting furnaces along lines of physico-chemical research. Prob-

lems involving reactions at high temperatures, heats of formation, solubilities and equilibrium conditions are deserving of much more intensive study and even though the original investigations may be of the pure science character, it will certainly result, as it has in other cases, that the pure science investigations can be translated into terms of practical manipulation and control.

I trust that Commander Rhodes' paper will stimulate an interest in such study and I am convinced that a more perfect knowledge of these matters would result in eliminating some of those things that we now term "peculiarities" in steel.

The Chairman (Mr. W. A. Rogers): The third gentleman discussing Commander Rhodes' paper is Mr. F. E. Clark, Electric Furnace Engineer, Milwaukee, Wisconsin.

Discussion by Mr. F. E. Clark

Electric Furnace Engineer, Milwaukee, Wis.

Commander Rhodes' paper covers such a wide range of subjects that it would be quite easily possible in a detailed discussion of it to write volumes. Accordingly my comment with the exception of a few generalities is confined to the acid open-hearth and basic electric processes.

The term "ordnance steel" might for the time being at least be supplanted by the expression "quality steel," as a great many commercial products require metal that will meet very severe specifications. It is not at all unusual at the present time for a buyer to submit photomicrographs of acceptable steel.

The big consideration in this instance being dirt, although the usual physical and chemical specifications likewise must be met.

Steel makers became quite familiar with the expression "dirty steel" during the period of the World War through their efforts to make ordnance products, principally guns and armor piercing projectiles. A great many

difficulties were encountered, most of which might be listed under the heading "internal defects," and included blow holes, dirt or non-metallic inclusions, fissures and woody structure.

Present day requirements for many products are equally exacting as those of ordnance steels at any time and the problem of how to best meet these requirements is becoming more acute each year.

The acid open-hearth process has long been used for the making of gun steel and although it possesses a few natural disadvantages has been very successful.

A few years ago Mr. Baltzar deMaré presented before this Institute an excellent paper on the acid open-hearth process, in which all details were very carefully covered. He, like Commander Rhodes, laid great stress on the reduction of silicon from slag to bath as a means of producing a well deoxidized and thoroughly killed steel. However, one very vital consideration in connection with this reaction was the presence in the initial charge of some 2% of manganese.

Without any question of a doubt initial manganese plays a very important part in the resultant quality of acid open-hearth steel, as it prevents excessive oxidation of the metal in the early stages and likewise minimizes the iron oxide content of the slag.

High temperature must be obtained in order to reduce silicon from acid slags and, in fact, it is hardly possible to obtain clean steel, the term being only relative unless the metal is fluid enough to permit ready separation of non-metallic particles.

Although the reactions of this process are inherently those of silicate formations, such silicates quite readily coagulate and rise rapidly to the surface under proper conditions of metal fluidity.

The laws of mass action hold true for furnace reactions and, although carbon acts as a deoxidizer to a considerable extent, its actual value in this respect is not comparable to manganese.

Acid furnaces require charges of high grade scrap and pig when quality steels are being made and the process, as is well known, is at a big disadvantage when low phosphorus and sulphur are desired.

The basic electric arc type furnace offers every desirable advantage for the making of "quality" steel.

Commander Rhodes has described the best electric steel as being that made with manganese reduction from slag to bath during the finishing period. It is my firm belief that the best steel is made with both manganese and silicon reductions from slag to bath. The matter of effecting a silicon reduction is not at all an impractical consideration when .35% or more of carbon is present in the metal.

There exists in the industry a general presumption that basic furnace linings are badly scorified by slags which contain some 35.0% of silica. This is really unwarranted as complete records are available of one furnace that operated for a period of at least one month on steels of .40% C. and under, in which a minimum of .15% of silicon was obtained on all heats by direct reduction. Slags during this period often ran over 35.0% SiO_2.

The presence of silicon which has been reduced from slags to the extent of .05% in the metal is ample indication in this process that oxides are at a minimum and that any further reduction may be considered unnecessary.

There are many factors to be considered in electric furnace metallurgy and perhaps at present the most notable is that of gas absorption by the metal during the various stages of operation. Excessive absorption of gases presumably H and N takes place occasionally under unusual conditions, but for the most part no serious difficulties are encountered on ordinary grades of steel.

This subject is really worthy of an extensive investigation especially in connection with high silicon steels.

I want to take this opportunity of commending Commander Rhodes for his keen interest in the development of electric steels for ordnance purposes.

THE CHAIRMAN (Mr. W. A. Rogers): We will now have the paper entitled Composition of Raw Materials and Pig Iron Costs, by Mr. Thomas T. Read, Acting Assistant to the Director, Bureau of Mines, Washington, D. C.

MR. THOMAS T. READ: Gentlemen: It has been your gracious custom to invite the Director of the Bureau of Mines to attend these meetings and to address you. He is of course sensible of the honor of being invited to speak before the Institute, which represents so large and so important a part of the mineral industry, and in previous years he has usually been able to attend. In these troublous times, however, when we seem to be tending toward a system of government by inquisition, it seemed impossible for him to be here on any specific date; so he asked me to represent him, however inadequately, at this meeting. I was glad to do so, of course, for the reason that I have recently been making some studies on the general economic aspects of the iron ore industry.

COMPOSITION OF RAW MATERIALS AND PIG IRON COSTS

THOMAS T. READ

Acting Assistant to the Director, United States Bureau of Mines, Washington, D. C.

The effect which the composition of the raw materials used has on the cost of the pig iron produced was forcibly called to my attention some months ago, when I was instructed to make a study of the broader problems involved in the beneficiation of low-grade iron ores. The fundamental question in beneficiation is how much more is the ore worth after beneficiation than it was before. To answer this question involves a critical study of the factors that enter into a determination of the relative worth of different grades of iron ore, coke, and stone; and a correct determination is by no means easy. The cost of these things, as delivered at the blast furnace plant, is not an index of their real worth. The price of the pig iron produced is determined by market conditions and the relative worth of different grades of raw materials can be accurately determined only by reckoning their relative effect upon the cost of producing pig iron from them.

Since raw materials are always used in combinations, it naturally follows that raw materials may have different relative worth to different people, if the combinations of which they form a part are different. A given raw material may in one combination serve to decrease the cost of the smelting operation and in another to increase it; its relative worth in the second case is less than in the first. The precise determination of relative worth, therefore, has to be made for a specified combination, but in

order to arrive at a precise determination it is necessary to consider the general rules which govern relative worth, as indicated by a study of average conditions.

The average conditions in smelting raw materials to make pig iron in this country, as set forth in the Annual Statistical Report of this Association, involve the smelting together of 3,950 pounds of iron ore, 345 pounds of ferrous material other than ore, 2,176 pounds of coke, and 970 pounds of stone, to produce a ton of pig iron. I am dealing with averages and therefore no distinction is made as to the grade of pig iron desired, since that is a factor which must be considered in individual cases. The average pig iron probably approximates to basic pig, since over 50 per cent of the metal produced is of that grade. There is no way of getting at the average composition of all the iron ore smelted in this country, but the ore produced in the Lake Superior region amounts to 85 per cent of the total, and for that we have, thanks to the Lake Superior Iron Ore Association, quite complete statistics. The Association's average figures indicate that the Lake Superior ore shipped in 1922 had the following average composition:

Fe (natural)	SiO_2	H_2O	P	Mn
51.87	8.23	10.78	0.099	0.76

There is no practicable way of getting at the average composition of coke or of stone, but we shall not be far wrong if we assume that coke on the average contains 86 per cent fixed carbon, 6 per cent silica, 2 per cent alumina, 2 per cent lime and 1 per cent sulphur. Coke as actually charged to the blast furnace contains a variable percentage of moisture, but where blast furnace records are kept on the basis of skip-loads this variable tends to cancel out, since the moisture does not affect the volume. For simplicity's sake the impurities in the stone will be neglected, for there is no known way of getting at average figures and the impurities are not important on the average, though they may be in individual cases.

Neglecting for the moment the iron in the ore and the carbon in the coke, the most important item in the list of components is the silica, both from the standpoint of quantity and the effect it exerts on the blast furnace process. It is the silica in the ore and the coke that makes the addition of stone to the charge necessary, so that the whole cost of stone in smelting might be ascribed to the silica in the raw materials. But we cannot deduce from this that, if we could eliminate silica from the raw materials, we could also eliminate the limestone and thereby greatly decrease the cost of pig iron, for the matter is not so simple. Sulphur, which is present in the raw materials in quite small amounts, has a tremendous effect on the blast furnace process. Sulphur has so bad an effect on iron and steel that specifications never admit of more than one-tenth of one per cent in the finished product and in rivet steel, for example, only one-twentieth of one per cent is admissible. Sulphur is so resistant to methods of removing it that the only good way is to keep it from ever getting into the pig iron; and this is one of the most important factors in blast furnace operation. What relation this has to silica in the raw materials is set forth as follows.

In a careful study of the operations of 38 blast furnaces, made by T. L. Joseph of the Bureau of Mines, and to be published later, it was found that over 90 per cent of the sulphur entering the blast furnace with the raw materials was brought in by the coke, and only 7 per cent by the ore. Less than 5 per cent of the sulphur charged is permitted to go into the pig iron, over 85 per cent goes off in the slag and the rest is unaccounted for. The blast furnace must get rid of over 95 per cent of the sulphur charged to it without letting it get into the iron. This makes it necessary to adjust both the quantity and composition of the slag. It must be higher in lime, so it will take up and retain the sulphur and it must be large enough in amount to take care of the total quantity. On the average, charcoal blast furnaces make only half as

much slag per ton of pig iron as coke furnaces, because they have to dispose of less sulphur.

This extra slag adds to the cost of the pig iron in a variety of ways. The slag-forming materials displace iron from the charge and cut down output, and what is much more important, they make it necessary to use additional coke to fuse them and this extra coke brings in more sulphur. In a recent paper (Reports of Investigation No. 2560, Bureau of Mines) Mr. Joseph and myself have computed that an extra pound of slag requires a little over a half a pound additional coke. As the slag of the 38 furnaces referred to above averaged 1.67 per cent sulphur and the coke about 1 per cent sulphur, the final outcome of increasing the slag and adding coke is the elimination of the sulphur, but at a heavy cost.

One pound of additional silica in the charge over the amount that gives the best results adds 1½ cents to the cost of a ton of pig iron through increasing the slag volume, according to the data in the paper cited above. One pound of sulphur added to the charge would add 0.85 of a pound of sulphur to the slag, which would require 50 pounds additional slag to carry it off without increasing the percentage content; and this slag would require 20 pounds more coke, which would bring in a quarter pound more sulphur, and so on. On this basis one pound of extra sulphur per ton of pig iron in the charge adds about 35 cents to the cost of the ton of pig iron.

One of the most important problems of the iron industry today is the securing of low-sulphur coke for blast furnace operation. This problem has been extensively studied by the Bureau of Mines and a number of papers on this subject by A. R. Powell and his associates of the Bureau Staff have been published.

The foregoing analysis gives us a general rule as to the amount of silica there should be in a blast furnace charge. There should be enough to yield a sufficient quantity of slag of the right composition to take care of the sulphur in the charge. Every pound of silica above

this amount in a sufficient weight of charge to yield a ton of pig iron adds 1½ cents to the cost of the ton of pig iron, or, putting it in another way, every pound of silica in an ore above the amount that gives the right slag volume takes ¾ cent per ton off the value of that ore to the blast furnace operator. The value of such an ore therefore depends on the charge combination in which it is used. To an operator who needs to get more slag volume a high silica ore is desirable, within limits; while to the man who has enough slag volume it makes an unwelcome addition to the smelting cost, unless it can be bought enough cheaper to counterbalance.

The ash constituents of coke seem small in percentage, but the tremendous effect of the sulphur has already been discussed. Six per cent of silica in the coke does not sound important, but it corresponds to 120 pounds of silica, or about 360 pounds of slag per ton of pig iron, and not only involves the adding of about 360 pounds of limestone to the charge, but requires 180 pounds of coke for the extra slag. Nearly 10 per cent of the coke required per ton of pig is needed only for fusing the ash in the coke itself. The coke needed to fuse the ash brings in more ash, and here again we have the situation that, as in the case of the sulphur, the remedy adds to the disease. In the case of coke that contains over 14 per cent ash not only is this difficulty accentuated, but S. P. Kinney has found, in an unpublished study of a single plant, that coke which carries over 20 per cent ash apparently produces a number of difficulties, due to altered conditions created in the bosh. At any rate every additional pound of silica in the coke not only means a pound less of carbon in the coke, but makes three pounds of slag, which calls for one and a half pounds more coke. On this basis, if 2,000 pounds of 86 per cent fixed carbon coke has cost $5.70 by the time it is in the blast furnace, then we are paying one-third cent per pound for carbon, and one pound additional silica in the coke will take seven-tenths cent off its worth to the furnace. Ten pounds of

silica more or less may seem a small matter, and yet a metallurgist will ordinarily devote a good deal of thought to the possibility of cutting his production cost seven cents per ton.

Any complete discussion of the problems set forth here would involve the discussion of a good deal of detailed technology, such as the part which manganese in the charge plays in aiding sulphur elimination, the effect alumina has on the slag and on sulphur elimination, what factors have to be taken into consideration in substituting magnesia for lime as a slag constituent, and the whole fascinating field of consideration of what actually happens inside the blast furnace, on which we seem to be in process of getting a good deal of new light. We also have to take into consideration the reliability of our figures. I have recently undertaken a study of the probable error involved in using, in blast furnace calculations, the average figure for a whole cargo of iron ore, and while the study is not yet completed, it indicates that the probable error (due to variability in composition) is many times larger in the case of the silica than it is with the iron. While the need is for more precise figures to permit more precise reasoning, it is felt that consideration of the broader aspects of blast furnace operation is also helpful, and it is for this reason that this discussion has been presented in the hope that comment and criticism will be evoked and lead to a clearer understanding.

The Chairman (Mr. W. A. Rogers): The schedule provides for no discussion of this paper. The next paper is entitled Hardened and Ground Rolls, by Mr. J. R. Adams, Superintendent, Research Department, The Midvale Company, Nicetown, Philadelphia, Pa.

HARDENED AND GROUND ROLLS

J. R. Adams

Superintendent, Research Department, The Midvale Company, Nicetown, Philadelphia, Pa.

For the purpose of this paper hardened and ground rolls are considered as forged steel rolls, hardened and drawn, the drawing being insufficient to make the rolling surface machinable, so that it must be ground to be finished.

As hardened and ground rolls are principally used in cold rolling, the early histories of hardened and ground rolls and cold rolling are interwoven. Some of the facts are here given.

Historical

The history of the cold rolling of metals is so indefinite that it has not been possible to credit any one individual or group with the invention or first use.

Since it antedates any general use of iron castings, it is probable that the first rolls used were made of steel. The hardening of steel had been known long before the recorded dates of the first cold rolling. Therefore, it is likely that the rolls were hardened.

Theophilus Presbyter, a monk, writing about 1100, describes a tool for the cold working of gold and silver, which he calls an "Organarium." The description of the design and the manner of working is not clear, but, from what can be gathered, the conception of the rolling mill could readily follow. An early definite description of rolling is given by that master Italian genius, Leonardo da Vinci, in 1495. His note books contain sketches of rolling mills for the production of sheet lead. Various

authorities state that Antoine Brulier, or Brucher, of France, the form of the name depending upon the nationality of the writer, was the first man to adopt the rolling mill for the production of mint flats of uniform thickness in order to make coins of equal weight. E. Schlosser, in Munztechnik, casts doubt upon this, stating that "It is uncertain whether the die cutter, Brulier, or the carpenter, Olivier, is the inventor." It is certain, however, that the mill was put in operation in France in 1552, under the direction of Olivier. It was imperfect and the operation so expensive that Henry III discontinued its use. In 1639, Warin improved this mill and again rolled flat bars for the mint. The mint at Hall in Tirol had a rolling mill in operation in 1575, described by Pighius in his Herculus Procidius. He states that the rolls were of the very hardest steel and were driven by water power.

Mills for the rolling of mint flats were in use in 1581 at the Pope's mint, in 1587 in Spain, and in 1599 in Florence. The mills for rolling mint bars were soon developed into mills for the rolling of other metals, and were in general use at the beginning of the 17th century. Solomon de Caus, in 1615, describes a hand-driven mill for the rolling of lead plates for organ pipes, while Zoncas, in 1621, notes the rolling of lead for glazing windows, and gives an elaborate description with sketches of rolling mills.

In 1728 Fayolle described before the Académie Royale des Sciences of France a remarkable reversing mill for rolling lead into sheets. The rolls were 12 inches in diameter by 5 feet long, and the mill was provided with a carriage with idle rollers to handle the sheets. The power was said to have been provided by horses. Figs. 1 and 2, taken from Machines et Inventions Approuvées par l'Académie Royale des Sciences, Volume 5, illustrate the construction of this mill.

In all of the above references there is no direct statement that the rolling was done cold, but from what we

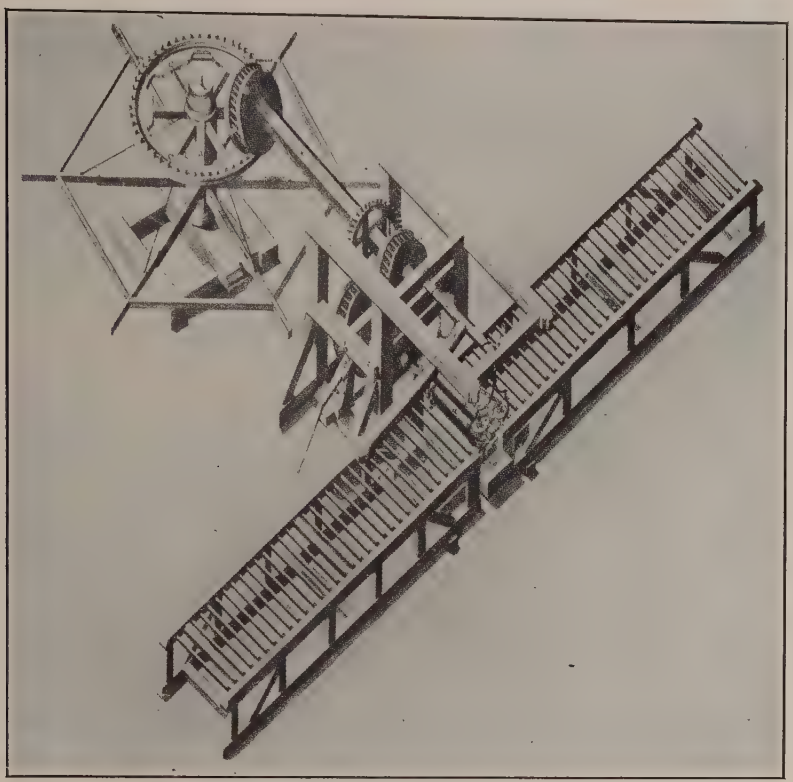


Fig. 1—French lead mill in 1728, general view.

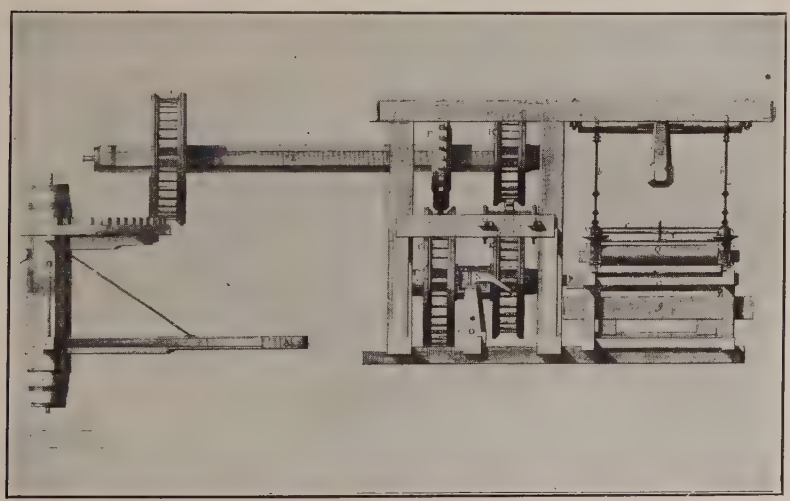


Fig. 2—French lead mill in 1728, side view.

know of the processes and Pighius's direct statement that the mill at Hall used rolls of the "very hardest steel," it would seem safe to assume so.

One of the first direct references to rolling iron or steel is by E. Hesse, who describes a rolling and slitting mill invented in Nurnberg, in 1530 or 1532. He states that the "turning wheels stretch the iron by great force." There is very little likelihood that any cold rolling is referred to here, but there is that possibility. That clock or watch spring steel was cold rolled at an early date is highly probable.

Among the early uses of the cold rolling of iron and steel was the smoothing of plates for tinning. In 1742, an English patent was granted John Baskerville, part of which applies to the cold rolling of sheets. Flower, in his History of the Trade in Tin, states that the practice of polishing iron plates by cold rolling was in vogue in 1747. In 1759, a patent was issued Thomas Blockley, which in part covered the polishing of rolls. In 1783, John Westwood obtained a patent for hardening and stiffening of copper, brass, iron, steel, etc., by cold rolling rounds and shapes, while later, in the same year, William Playfair took out a patent in which cold rolling of flats and rounds to obtain a finished surface was mentioned. With respect to the rolls used at that time, Christopher Polhem (1720-1746) states that forged steel rolls were then in general use. They were machined, quenched and polished. The rolls were up to 7″ diameter in size, and the quenching was done in water or oil. Cast iron rolls were also in use.

By 1800, the cold rolling of metals was in general use for iron, steel, brass, foil, etc. The rolls were not very satisfactory. The chilled iron roll had come largely into use, but the surfaces of the rolls and their hardness left much to be desired. The trades of the gold and silver melters, button makers, tinkers, and mints were badly in need of small rolls which presented an absolutely clean surface of high polish, and, at the same time, were

uniformly hard. Thus, the roll situation was ripe for the forged steel roll made from cast steel. To this problem the Germans turned their attention, and they were the first to attain a conspicuous degree of success in making the forerunner of the modern hardened and ground roll.

Among the earliest Germans to attempt the manufacture of hardened steel rolls was Friedrich Krupp. He, however, died before attaining any prominence in roll manufacture, and it was left to his young son, Alfred, to establish the great Krupp steel works on hardened and ground rolls. Had it not been for hardened and ground rolls, it is doubtful whether the infant cast steel works would have survived.

In 1817, Krupp sent a couple of wrought cast steel cylinders to a rolling mill in the wire industry. Whether they were successfully made into rolls, records do not state. At the instigation of Noelle, mint assayer of Dusseldorf, Krupp sent a pair of rolls there in 1818, and a number later. They were usually delivered in blocks about 3″ thick, and were turned and hardened in the mint. The earlier rolls made by Krupp were not entirely satisfactory. They were loose in texture, irregular in the core, and the breakage in hardening was high. But since the surfaces of the chilled iron rolls were not good enough to be used efficiently in rolling out gold, silver, copper, watch spring steel and polished brass, Krupp was encouraged by the mints and metal trades to continue his work.

Krupp's water-driven tilt hammers were not heavy enough to forge large ingots properly and defective centers were the usual cause of his early rolls breaking in hardening. With this in mind, Krupp made several cast steel rolls from an alloy of steel and copper. The first were sent to the mint assayer Bruel at Hanover, who found they had sufficient resistance to wear without subsequent hardening. These were the first alloy steel rolls. Krupp later abandoned this practice, returning to the

forged steel rolls, but for a number of years some of his customers that had used these rolls specified them on their orders.

In 1826 and 1827, several brass factories in the neighborhood of Essen ordered rough forged steel rolls from him. The largest of the rolls cracked in hardening, which led Krupp's cousin to advise him to forge steel rolls into squares or octagonal bars in order to keep the centers sound and thus decrease the hazard of hardening to a minimum: advice which Krupp followed and which is constantly kept in mind in forging to this day.

Krupp guaranteed his rolls probably in a manner similar to manufacturers of today. This compelled him to replace rolls broken by his customers during hardening, and, in order to diminish his losses from this cause, he decided to complete his own rolls; so, in 1830, he advertised his ability to furnish hardened and polished rolls. In August of that year, he sent out his first rolls in that condition, but, due to breakages in hardening, they were manufactured at a loss, an experience that is not uncommon to the roll manufacturer of this day. In 1830, Krupp made his first hollow forged ring rolls. In 1832, the first mechanical workshop of the Krupp plant was built for the machining and grinding of rolls. In 1834, Krupp sold his first tinsel rolls, again at a considerable loss. At this time the demand for larger and larger hardened and ground rolls increased so rapidly that Krupp was compelled to develop the multiple pot ingot.

Krupp cut down his losses considerably by furnishing rolls already hardened and ground, but was soon confronted with the trouble that imperfect mills caused his rolls to fail when operated in them. The desire to protect his rolls and to increase the market for them caused Krupp to enter the field of supplying complete rolling mills. Thus, hardened and ground rolls were the direct cause of Krupp entering the field of machinery manufacture.

It would be foolish to assert that hardened and ground

rolls were responsible for the growth of the great Krupp steel works, but they must be credited with keeping it alive during its earlier years, since they were its principal, and during certain periods its only product. Krupp always felt that the manufacture of hardened and ground rolls was of great importance, always hardening them himself while still actively connected with the operation of the works.

As late as 1870, Alfred Krupp wrote: "This manufacture requires more attention, more delicate treatment than the usual articles; it demands thought, practice and skill and enhances progress."

Even as the date of the first cold rolling in Europe is shadowed in doubt, so the date of the first cold rolling in this country is obscure, its history not having been considered by most chronologists. Inquiries and searches so far indicate that the first cold rolling of iron or steel of the nature performed by hardened and ground rolls was done by the Washburn & Moen Company, in Worcester, Mass., now the North Works of the American Steel & Wire Company, where round wire was flattened between rolls in 1859 for the production of crinoline wire for our grandmothers' hoop-skirts.

This statement would seem to disregard Bernard Lauth's work at the American Iron Works, in Pittsburgh, Pa., between 1854 and 1859, at which time his patent was granted. The patent, however, appears to cover theoretically the enhancing of physical properties from cold work. So, for the present at least, the honor of having done the first real cold rolling of iron or steel in this country appears to rest with the North Works of the American Steel & Wire Company.

The first consistent cold rolling of brass was done by Abel, Porter & Company, of Waterbury, Conn., between 1802 and 1808. The Scoville Manufacturing Company is the continuous successor of Abel, Porter & Company.

Among the early hardened and ground steel rolls manufactured in this country were those made by the

Miller, Barr & Parkin Company, of Pittsburgh, Pa., for the United States Mint, in 1869. The work was directed by Mr. Charles Parkin, assisted by Mr. Samuel Trethewey. About 1880, Mr. Trethewey left Miller, Barr & Parkin, and started in the manufacture of rolls and shear blades in his plant at Lawrenceville, near Pittsburgh, Pa. He supplied rolls to various companies in that neighborhood for some time.

In 1872 or 1873, the first strip steel was rolled for Miller, Barr & Parkin, of Pittsburgh, Pa., by Samuel Spurrier, brought from England by the above company for this purpose. The material rolled was shank steel for shoes, corset steel and clock steel. Hardened and ground steel rolls were used from the start, due to the difficulty they experienced in getting chilled iron rolls free from surface imperfections.

In 1877, the first mills of the American Belt, Tin & Tube Company, Bridgeport, Conn., were built, and in 1878, the first strip steel was rolled for the market. It is thought that the rolling was done with steel shell rolls. It is definitely known that the Wasburn & Moen Company adopted the use of steel shell rolls about 1880. In 1885, the John A. Roebling's Sons Company bought a water-cooled cold rolling machine from the Blake & Johnson Company that was put in operation sometime between then and 1887. Their first cold rolling was done with hardened steel rolls.

Shortly before 1871, Mr. William H. Hart of the Stanley Works, wishing to duplicate the finish on imported steel sheet from Europe, attempted the drawing of steel through burnished dies. He did not achieve the desired results, but decided that rolling would give him the finish he wished. With this end in view, he obtained two small rolls, and, in an experimental way, cold rolled steel in the Stanley Works. He was so successful that, in the year of 1871, he sent steel to a neighboring brass mill to be rolled on its mills. This rolling was done with

chilled iron rolls, and continued until the Stanley Works was equipped with cold rolling machinery.

In 1887, the Morris & Bailey Steel Company started to roll strip steel with chilled iron rolls, but changed in 1888 to steel rolls made by Mr. Trethewey.

Among other early cold rolled strip steel manufacturers are the Superior Steel Corporation and the West Leechburg Steel Company.

Hardened Steel Rolls and Chilled Iron Rolls Compared

Cold rolling for which hardened and ground rolls are used today is fundamentally the same as in the early development. High finish, reduction, exactness of gauge, enhancement of physical properties are desired, and any one, or combination of the above properties, may be the object. The work required of modern rolls for strip steel rolling, in which we are here chiefly concerned, is even harder and more exacting. The mills of today are more powerful, run at higher speeds, make larger reductions, while a higher finish and more exact gauge are required. Hardened and ground rolls are now able to do this harder and better work, owing to their superior hardness, strength, purity of surface and greater depth of hardness. They have practically displaced their old competitor, the chilled iron roll, for the intermediate and finishing passes in plants specializing in producing a high quality, cold rolled steel product.

Hardened and ground rolls differ from chilled iron rolls in that they have greater hardness, more homogeneous surface, greater strength and longer life. These advantages enable the hardened and ground roll to turn out a greater production than chilled iron rolls. The journals wear less than those of chilled iron rolls, thus enabling the gauge to be maintained with greater exactness. A good surface can be obtained from some chilled iron rolls at the start of rolling, but it rapidly deteriorates. On the other hand, the high finish required is

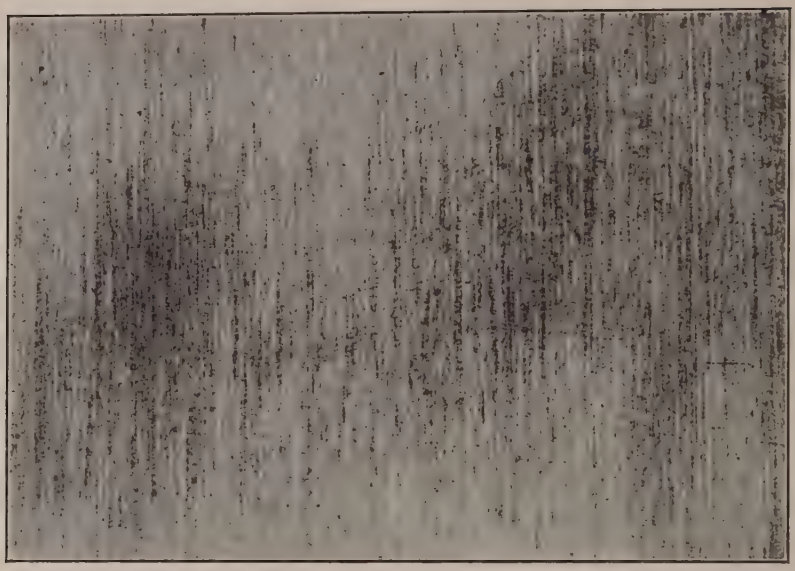


Fig. 3—Surface of cold rolled strip steel rolled with a hardened and ground roll. Magnification, x5.5.

Fig. 4—Surface of cold rolled strip steel rolled with chilled iron roll. Magnification, x5.5.

more easily obtained from hardened and ground rolls and can be maintained over a considerable period of time. They require less roll changing, fewer grindings, and, usually, the removal of less material by grinding to restore the surface, thus increasing their life. Hardened and ground rolls withstand greater reductions for a longer time than chilled iron rolls, without deterioration of surface or loss from breaking and spalling. In the more progressive mills, the hardened and ground roll is also gradually replacing the chilled iron roll for the roughing passes as well. When hardened and ground rolls are used in this work, greater reductions are made, the number of passes cut down, and a superior final finish may be obtained.

Fig. 4 illustrates a surface produced by a chilled iron roll, magnified 5½ diameters, while Fig. 3 is a surface produced by a hardened and ground roll magnified to the same diameter. The steel strips were rolled by different mills and with different reductions, but they are commercial surfaces produced by the two kinds of roll.

Composition

As the modern use of hardened and ground rolls developed, the manufacturers of them were compelled to abandon the plain carbon steels and adopt alloy steels to meet the more exacting requirements. Naturally, a number of different compositions have been used by various makers. The analyses of some of these, determined between 1900 and 1910, are as follows:

	C	Mn	Si	Cr	W	Ni
European roll	.98	.37	.31	2.32	.....	.....
European roll	1.77	.28	.15	.....	2.75	.....
European roll	.88	.22	.29	2.07	.....	.....
Unknown roll	.68	.25	.17	2.09	.....	.....
Unknown roll	.92	.26	.27	2.28	.....	.....
European roll	.91	.40	.26	1.92	.....	.....
American roll	.99	.35	.26	1.90	.....	.....
American roll	.90	.35	.17	2.49	.....	.....
American roll	.89	.18	.24	2.28	.....	.....
German roll	.67	.35	.39	1.93	.....	.14

Since that time, roll manufacturers have adopted compositions that will more or less fall within the following limits:

C	Mn	Si	Cr
.70 to 1.25	.20 to .40	.15 to .30	1.50 to 2.50

We, however, do not believe the above is the last word in composition for rolls, and are continually experimenting to obtain a composition that will produce a better roll. The results of some of these experiments will be mentioned later.

From the viewpoint of excellence, the hardened and ground roll is a product typical of the best in the art of

Fig. 5—Ingot for a hardened and ground roll.

steel making. The alloy steel used is one of superlative purity, and excels in the qualities of strength and hardness. The raw materials used in melting are carefully selected and every care is exercised to melt and refine a steel of the highest quality. The greatest precaution is taken in casting the ingots to see that the cleanliness of the metal obtained in melting is transmitted to the solid steel in ingot form. The structure of the ingot is of utmost importance, and the type of mold used and the manner of casting are given every consideration. Methods of forging have been developed to produce the best

possible type of forging structure. Only the proper execution of all these operations will give an article of the cleanliness and homogeneity of a first class hardened and ground roll.

Melting and Forging

Hardened and ground rolls are usually made from electric furnace, acid open-hearth, or crucible steel. The cleanliness of the surface and the final completion of the roll depend upon the character of the molten metal made, and the manner of pouring it, so that too much emphasis

Fig. 6—Forging for hardened and ground roll.

cannot be placed upon the cleanliness in both operations, or excessive loss due to imperfect surfaces will eventually occur. The ingots are usually cast in such a size that the reduction in forging is not less than 3:1.

High carbon chrome steel ingots are exceedingly sensitive, so are usually charged hot in the forging furnace, when it is certain that the center is no longer fluid. As the hazards of forging large masses of high carbon chrome steels are considerable, the heating must be done slowly and the ingot thoroughly soaked out before forging. The fewer heats necessary to finish the forging

operation the better, and the furnace should be large enough to contain the entire forging at all times. Large rolls should always be forged under a press, and it is much better for the smaller rolls. In our practice, the forging of the rolls is usually done under a 3,000-ton press or 1,200-ton press, depending upon the size of the piece.

These precautions in forging have developed the practice of forging straight cylinders rather than to forge to the approximate shape of the roll.

Annealing

The finished forgings are usually not allowed to become cold before annealing. They are charged immediately into an annealing furnace heated to a temperature below the critical. The annealing operations should be extra thorough and care should be taken that the forgings are held long enough above their critical temperature to completely remove any trace of forging structure. This is usually longer for chrome roll steel than ordinary steel. The beneficial results obtained by prolonged annealing were very forcibly brought home to us some time ago by a change in the annealing of the large roll forgings, which greatly reduced the loss in the hardening operation and the number of retreatments. In cooling from the annealing temperature, precautions must be taken to see that no strains are set up in the forgings and that they are soft enough to be readily machined.

It is a good precautionary practice to make a microscopic examination of test pieces taken from the forgings after annealing, to determine the efficiency of the anneal, and the cleanliness of the metal.

Machining

After annealing, the forgings are preliminarily machined in heavy duty lathes, sufficient material being left above the finished size to allow for further heat treatment, and an axial hole is bored through the rolls to per-

mit examination of the interior for defects by means of a bore searcher. The machined surfaces should not be rough, lest the efficiency of the subsequent heat treatment be diminished.

Further Heat Treatment

As the annealed structure is one that does not best withstand the final drastic hardening, it is usually necessary to further heat-treat the rolls before hardening. This treatment generally takes the form of one or more quenches and draws, depending upon the size and type of the roll. The quenching medium is usually oil, but some form of water quench may be used. A rapid quench is desirable to obtain a good structure, but the design of the roll must be considered, or breakage may result from too severe a quench, since the material is very susceptible to cracking. The drawing temperature is such as to leave the journals of the roll the proper hardness. If the draw is too high, the journals will be too soft, and excessive wear will occur in use, defeating one of the objects in using a hardened and ground roll.

In order to determine that the heat treatment given the roll has attained its object, a specimen for microscopic examination is taken from every roll.

Figs. 7 and 8 illustrate a properly annealed and heat-treated structure. The photographs were taken by Mr. Harry S. George, of the Union Carbide & Carbon Research Laboratories, by his conical illumination method, described in the "Iron Age" for February 7, 1924. Comparing the photomicrographs taken under conical illumination with those taken under vertical illumination (Figs. 7-a and 8-a), the superiority of Mr. George's method can be seen. Examination of specimens by this method has convinced us of the value of the conical illumination over the vertical illumination, and we are now investigating it with the idea of further improving the manufacture of rolls.

After treatment, the radii on the ends of the body

— Annealed structure of roll forging. Conical illumination. x2000.

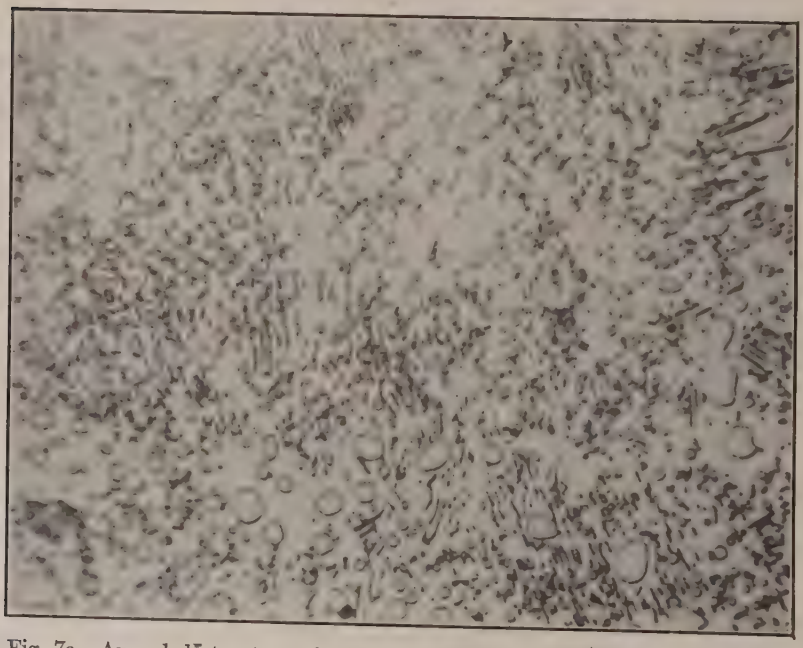


Fig. 7a—Annealed structure of roll forging. Vertical illumination. x2000.

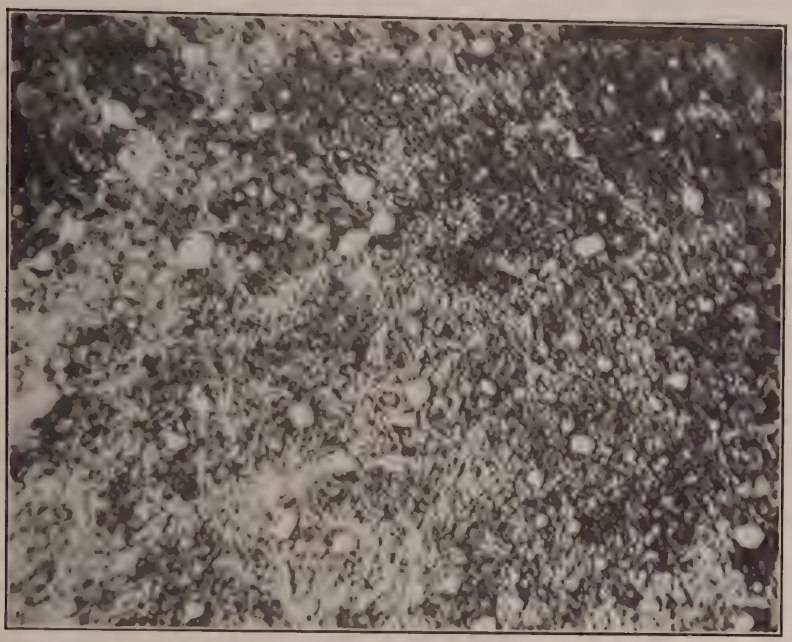


Fig. 8—Quenched and drawn structure. Conical illumination. x2000.

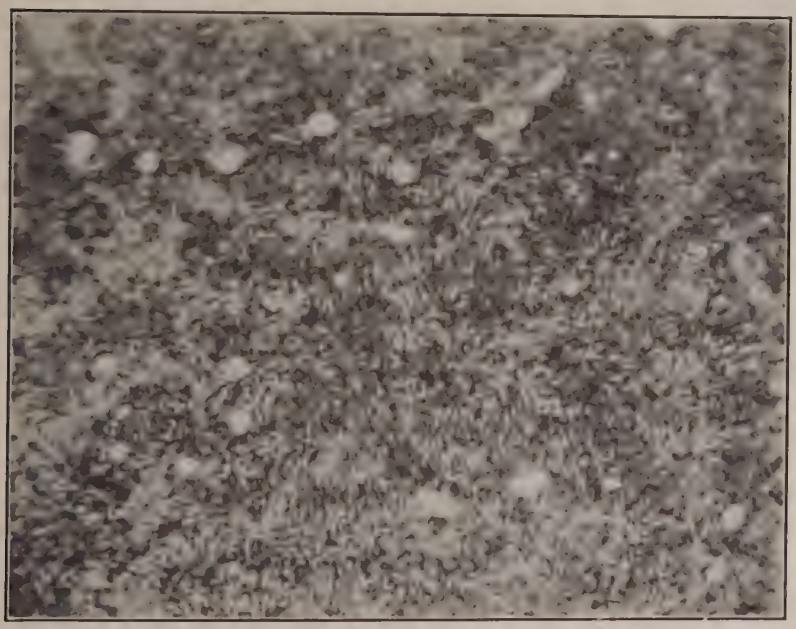


Fig. 8a—Quenched and drawn structure. Vertical illumination. x2000.

and the fillets between the journal and the body are properly formed to protect the rolls during final hardening. The radii on the ends of the body can usually be fairly large, since rolls are rarely used near the edges.

Hardening

The hardening to the maximum degree of a mass as large as even a small roll is no easy matter, and when this mass becomes as large as a roll 24″ in diameter by 46″ long in the body, the difficulties are considerable, to say the least. Long experience and the most careful supervision are required to be reasonably successful. The hardening is carried out in various ways by different manufacturers. A water dip, either still or agitated, water spray or submerged spray are all used. The size, design and hardness desired all dictate the method that can be used successfully. Many large rolls cannot yet be quenched in a spray with consistent success, while the smallest rolls do not usually require spraying. The largest rolls may have to be hardened by a water dip, or even in oil. When this is done, a sacrifice in hardness must be accepted. In this connection it is of interest to note that Mr. H. A. Brustlein, of Jacob Holtzer & Company, Unieux, France, was the first person to notice that some of the hardness of chrome steel is sacrificed if the rolls are not quenched in a spray. As already said, the hardening of a mass as large as even a small roll is no easy matter. The heating and quenching time for the various sizes of rolls, quenched by different methods, must be worked out experimentally with great exactness, in order to prevent breakage and obtain the maximum hardness. After hardening, the strains must be relieved without materially decreasing the hardness of the roll. For certain purposes, it is not desirable or necessary to furnish rolls of the maximum hardness, in which case they can be given a low draw. Some rolls have to be finished with hardened journals, in which case it is necessary to harden them all over. This increases the

hazard considerably, but it can be done, and a number of hard journal rolls are now made. Fig. 11 illustrates the microstructure of a hardened roll near the surface.

Difficulty in hardening is sometimes encountered, due to the design of the rolls. Sharp angles, deep tapped holes near the surface of journals, thin sections produced by large counterbores for water-cooling attachments, light sections in wobblers, all add to the risk in hardening, particularly in rolls that require hardened journals. Rolls are manufactured according to the orders of the roll users, or manufacturers of rolling mills, so that the design cannot usually be altered for hardening, and in many cases the roll designer seems to have failed to give due consideration to the hardening problem.

Hardness Determination

After hardening and relieving the strains, the scleroscopic hardness of the rolls is determined for every inch on paths running the full length of the body. The number of paths varies from four on the smaller rolls to eighteen on the larger rolls. If the scleroscope does not indicate the proper hardness or shows any non-uniformity, the roll is softened and rehardened. Scleroscopic readings are apt to vary, if the conditions under which they are taken are not rigidly standardized. We have standardized our conditions by always using the same scleroscope, and always, before using, checking it on blocks of the same size, material and hardness as medium diameter rolls.

The test blocks have been standardized by the makers of the instrument. If check readings indicate that the instrument is not reading correctly, it is sent at once to the laboratory to be cleaned and put into proper working condition. In damp weather this may be six or more times during the day.

The foundation on which the rolls rest during scleroscopic determination is always the same. The scleroscope is always used in the stand illustrated in Figs.

9 and 10, which we have adopted for this work. These precautions will give reasonably accurate results on rolls.

Grinding

If the scleroscope indicates that the rolls are of uniform and proper hardness, they are sent to the grinding department. There always has been, and probably always will be, considerable controversy as to whether

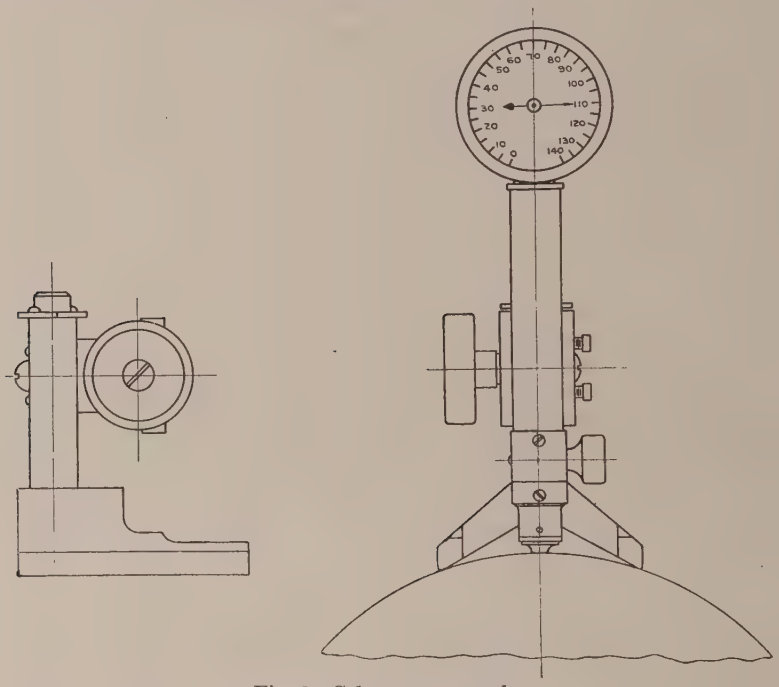


Fig. 9—Scleroscope stand.

rolls should be supported on the journals or on the centers for grinding. If journals are round, or if the centers are properly designed and made, one method is probably as good as the other; but, when a roll has been in service and the journals worn, slightly or much, the journals should be ground true before the roll bodies are ground supported on the journals. This a number of roll users fail to do. The journals rarely wear uniformly, and, if not ground true before grinding the body, the body of

Fig. 10—Scleroscope in stand on a roll.

the roll will not be a true cylinder. This will result in an uneven pressure being brought to bear on strip being rolled with a consequent variation in gauge, and may even cause injury to the roll. On the other hand, grinding on centers is not open to these objections. With roll centers properly made, and kept in good condition, and the grinder centers kept properly seated, the bodies of the rolls will be true cylinders. Here, too, if the journals

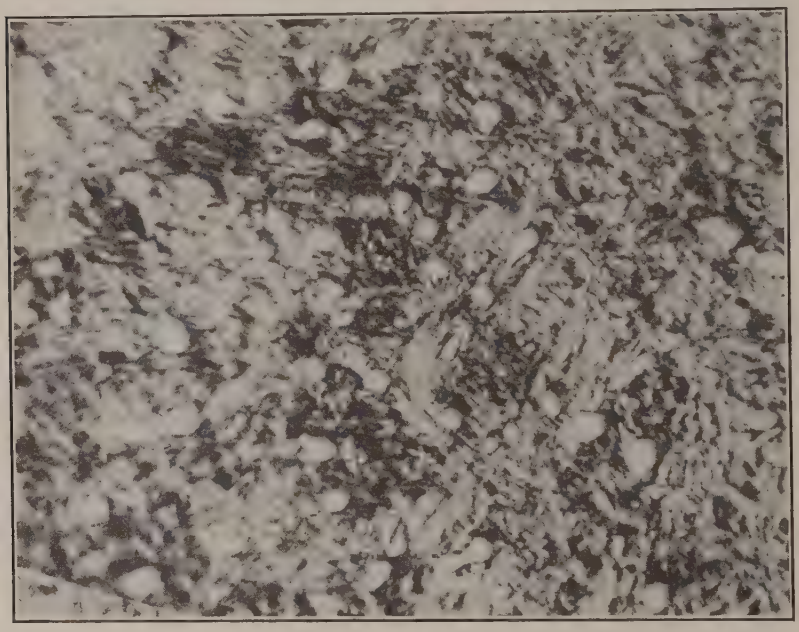


Fig. 11—Structure near a hardened surface. Roll undrawn. Conical illumination. x2000.

are worn, they should be trued up on the centers, or the roll body will run out in the mill, but not to the same extent as when ground by the other method.

Hard tool steel centers are much the best for rolls, as they do not wear as rapidly; however, for small rolls, soft centers are satisfactory. The design of centers is quite variable, the usual angle being 60 degrees. They may be permanent or removable for water-cooling of the roll during operation.

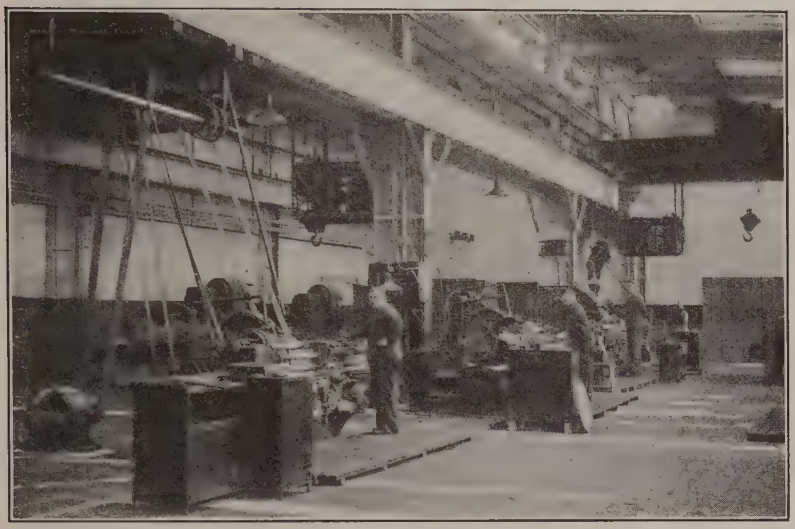


Fig. 12—Battery of roll grinders.

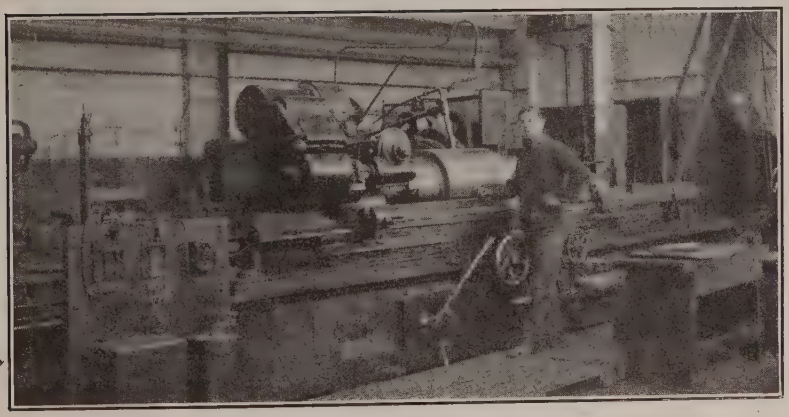


Fig. 13—Grinding a 16″ diameter roll.

Rolls that have been made from excellent steel and have come safely through all previous operations can be entirely ruined in the finish grinding by using improper wheels, speeds or cuts. The rough grinding should be done with coarse, soft, free-cutting wheels, kept well opened at all times. The finish grinding is done with harder wheels, but it is necessary to take lighter cuts. If too heavy cuts are taken with a fine hard wheel, small hairline cracks and pits will develop. It is best to remove all but the last few thousandths with the roughing wheel before applying the finishing wheel.

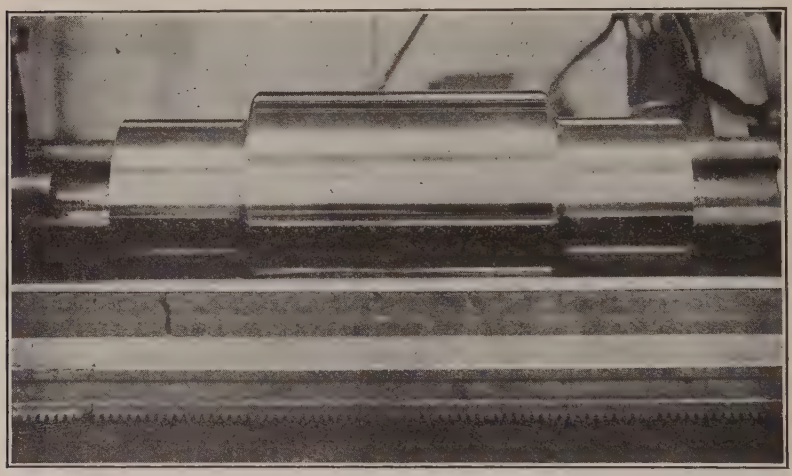


Fig. 14—Finished roll with silver-mirror surface.

The finished surface is of great importance. In most cases, rolls are furnished with a high finish, although this is not necessary for some users, since they grind special crowns on the rolls before they put them in operation. Unless otherwise specified, rolls are usually ground straight and furnished with a silver mirror finish.

After grinding, the rolls are slushed to protect the surfaces from rusting, and the final machine work is done, such as that for the attachment of water-cooling apparatus.

Use of Rolls

The character of work expected of a roll should always be considered before specifying the hardness.

Since surfaces are of paramount importance, rolls are usually guaranteed in this respect. In investigating failures and following the service of a great number of rolls, it is evident that some users of rolls are not familiar with the care that should be given them; nor do they realize that hardened and ground rolls have to be more delicately handled than ordinary rolls to obtain the best results. In some cases, it has been found that the user had over-estimated his hardness requirements, and a scleroscopic reading of 110 was not needed or desirable. A reduction in hardness, the amount depending upon the problem in hand, has usually removed the cause of complaint.

Sometimes slight changes in design of the rolls have served to improve their life and prevent annoying minor mishaps. Up to several years ago, a number of users ordered their rolls with sharp corners on the ends of the bodies, and no fillet between the journals and the bodies. Hard steel abhors sharp angles and a great many of these rolls spalled on the corners. In some cases, these spalls ran in on the body for some distance, with the consequent loss of the roll. This type of roll has practically been discontinued in the larger sizes, and even the small rolls are now furnished with at least some rounding of the corners. However, this matter of the fillet and radius can be carried too far. When the fillet is large and the difference in diameter of the body of the roll and the journal is small, there is no end-thrust bearing left between the body radius and the journal fillet. Several rolls of this design have shown excessive checking on the surface of the fillet and in some instances it appears as though local over-heating at this point has been the cause of rolls spalling. It may be that in the absence of an end-thrust bearing a combination of forces occur at this point, which brings on the over-heating. Some users of

rolls state there is no necessity for making an exact fit between the roll fillet and the corner of the bearing, while some few even advocate chamfering off the corner of the bearing, so there will be no contact between the bearing and the fillet, as shown at "B," Fig. 15.

Improper lubrication of roll journals and wrong adjustment of the bearings are prevalent causes of roll failures in cold rolling. One user states that in a great majority of the cases of spalled rolls that have come to his attention the journals of the rolls have shown signs of over-heating, and when the spall is near the end of the roll the adjoining journal has shown the greatest

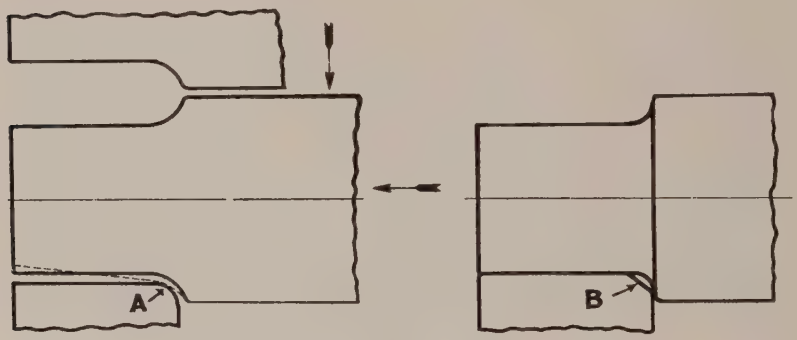


Fig. 15.

abuse from lack of proper lubrication. When rolls show a tendency to over-heat on the necks, the lubrication should be looked to and water-cooling of the journals considered. The design of the bearings and the material of which they are made has a great influence on the heating and wearing of roll journals. Types of boxes and bearing metals that have proved satisfactory for iron rolls are not necessarily suitable for steel rolls.

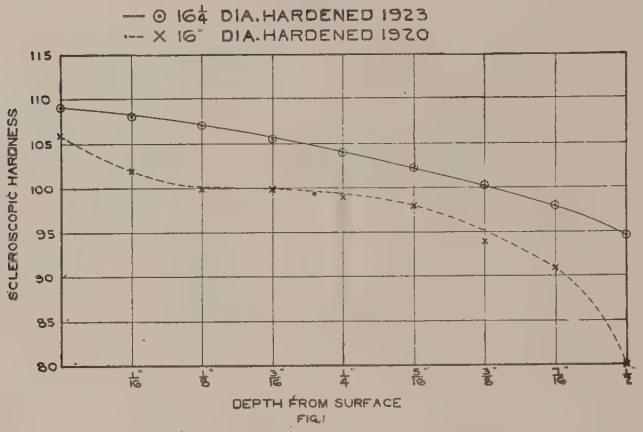
When narrow strips are being rolled and the highest finish is not required, there is a tendency in most mills to roll too long on one journey on the roll. It must be remembered that the destroying of the surface is a breaking down of the metal, and this increases in extent the longer the roll is used at this point. If the roll is

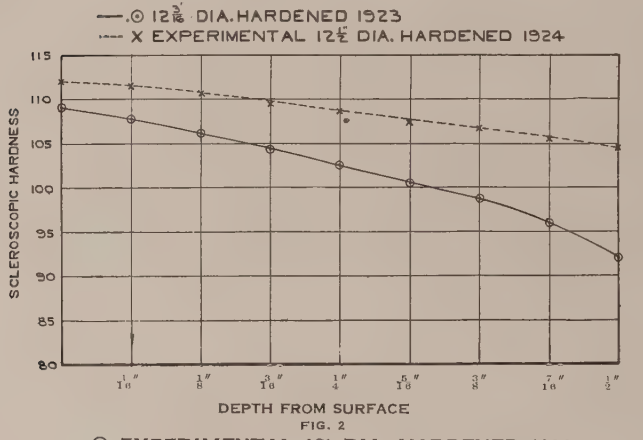
used too long in one spot, the breaking down will extend an appreciable distance below the surface and small checks appear. When this happens, more metal will have to be removed on dressing the roll than would have been necessary had the rolling been stopped at the proper point. Further, in such a case a clean surface may be obtained on regrinding that would seem to be satisfactory, but often the effect of the previous over-working is still there and makes itself apparent by the early reappearance of the checks,—or even spalling may occur.

Before starting to roll, it is generally considered good practice to heat rolls slowly to the temperature they will reach in operation, which insures the roll against sudden localized heating. It would appear better practice to warm the rolls from the inside through the bore rather than from the outside. Due to the hardness, the outside shell of the roll is in compression; therefore, heating from the inside will tend to relieve the stresses evenly. The practice of warming the roll by screwing down on the necks and running them face to face is very bad, and leads to excessive breakage. If, after warming the roll, the rolling operation would still further heat it, water-cooling to keep the roll at constant temperature should be used. Rolls that are run at high speeds and which reach temperatures of 400° to 500° F. cannot be expected to hold their extreme hardness. When rolls have been allowed to become cold during idle periods, the above precautions should be strictly observed before starting to roll again.

During rolling, there is a decided creep of the surface of the roll around the center. This is illustrated in Fig. 16. The dotted line shown is straight and passes through the center of the roll axis before the roll is put into use, but after use it will be found to have changed to the position of the solid line. This fact is recognized in some mills, and they run their rolls in

Fig. 16.





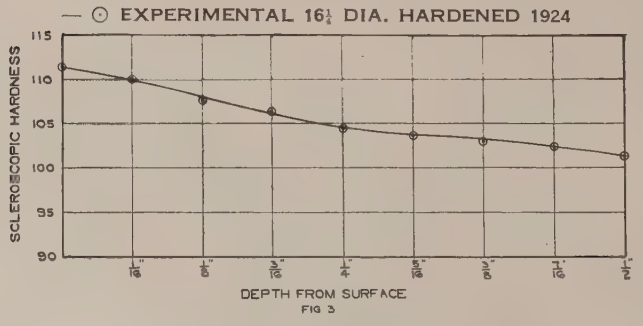


Fig. 17—Depth hardness curves.

one direction only, reporting that the adoption of this practice has given very satisfactory results.

Within the last few years, development and expansion of strip steel rolling has been considerable, and in order to keep pace with it, the manufacturers of rolls have raised their standards. Much of this improvement has been made by increasing the depth hardness. Some of the results are illustrated in the depth hardness curves shown in Fig. 17. The lower dotted curve of Fig. 1 shows the depth hardness of a 16″ diameter roll made in 1920.

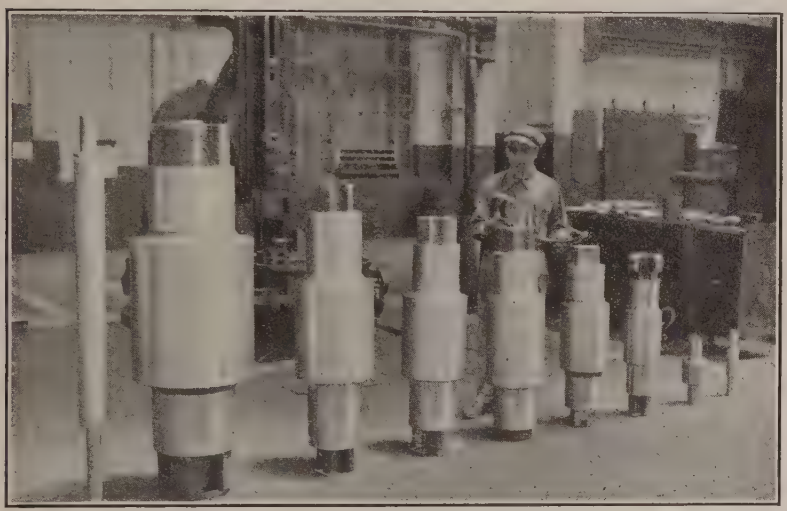


Fig. 18—Hardened and ground rolls.

Through changes in manufacture, this has been considerably improved upon, the depth hardness at one-half inch being raised from 80 scleroscope to 95 scleroscope, as shown by the upper curve in Fig. 1. Fig. 3 illustrates that this may be further improved in the future, if the methods that were used to make this roll can be applied to actual practice. The lower curve in Fig. 2 shows the depth hardness of a 12″ roll made in 1923, while the upper curve shows what has been accomplished experimentally up to the present in this size of roll.

Due to the density, it was thought that high speed steel might be used to advantage for some types of rolls. We have made a pair of ring rolls for a manufacturer rolling high carbon round wire into flat wire. These rolls were 7″ O.D. x 3½″ I.D. with a breadth of face of 4″. The user reported that they required grinding only half as often as other rolls he had been using on the same work. Other experiments for the use of high speed steel in rolls are now under way, but, owing to the difficulties

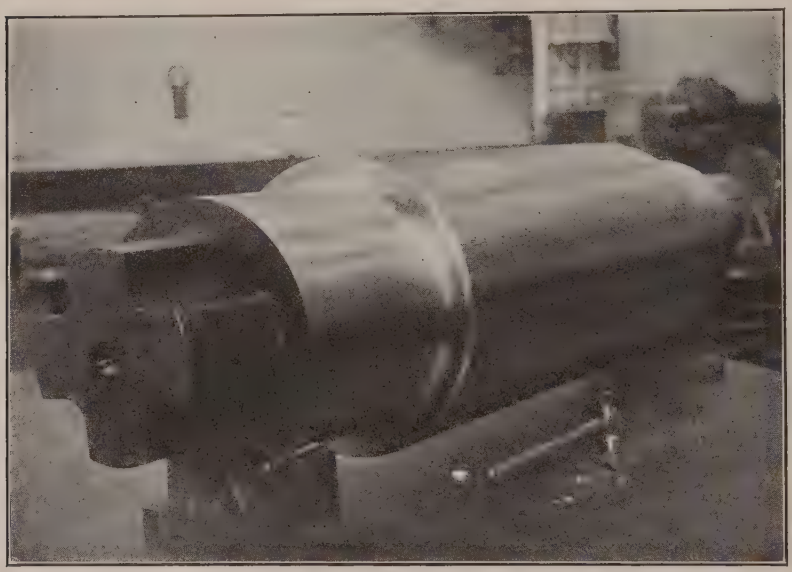


Fig. 19—Hardened and ground roll, 20″ diameter and 40″ body length.

of hardening large pieces of this composition its use will probably be confined to the smaller rolls.

Fig. 18 shows rolls of a number of different shapes and sizes. These rolls are all hardened and ground and are of various degrees of hardness to suit the work for which they are intended.

While hardened and ground rolls do not lend themselves to operations where temperatures attained will destroy their hardness, there are many industries, other than strip steel rolling, in which the properties of

strength, super-surface, hardness and long life of hardened and ground rolls are being used to advantage. Rolls are being successfully furnished to the paper industry, stationery manufacturers, tinning trade, jewelry trade, asbestos manufacturers. They are also being used for the cold rolling of nickel, gold, silver, platinum, zinc, brass, copper and foil. Large rolls with an engraved surface to produce a pattern on the rolled product have also been manufactured.

The Chairman (Mr. W. A. Rogers): The discussion of the paper on Hardened and Ground Rolls is by Mr. F. C. Elder, Metallurgist, American Steel and Wire Company, Pittsburgh, Pa.

Discussion by F. C. Elder

Metallurgist, American Steel & Wire Company, Pittsburgh, Pa.

The very interesting paper by Mr. J. R. Adams shows us the thought and care that must be put into the manufacture of hardened and ground rolls in order to insure high quality.

Let us now follow these rolls to the plant of the cold rolled steel strip manufacturer, and find out the conditions of service these rolls have to meet and why an exceedingly high quality of hardened and ground roll is needed.

The users of cold rolled strip steel, especially those who electroplate their product, demand a very high finish in strip steel in order that they may produce a product of high surface lustre, without having to introduce costly extra processes in their manufacture. Cold rolls in their operation imprint, in the strip steel being rolled, the slightest scratches or other surface imperfections on the body of the roll. So sensitive is this printing effect, that even a finger print stain on the surface of the roll will be transmitted to a highly finished cold rolled strip for a few revolutions of the roll. This will make clear, therefore, why such a mirror-like finish is required on cold rolls.

The length of time a working finish can be maintained on the rolls varies with the quality of the rolls, the hardness of the steel being rolled, the amount of reduction, the lubrication of the rolls, the quality of finish desired on the cold rolled strip, whether a roughing or a finishing pass, and upon several other factors. Heavy reductions on narrow width, hard material will destroy the surface of the roll more quickly than light reductions on soft material. Low carbon steel in soft condition will test 14 to 16 scleroscope, and the hardest material we have rolled will test 45 to 54 scleroscope. We have had instances in rolling soft steel where a workable surface has been maintained on the rolls for three months, and other instances where the rolls would have to be changed after rolling the first bundle of strip, due to the softness of the roll or the character of the material being rolled. On the average, however, a roll will have to be taken out and reground after about thirteen days of rolling service.

The amount of regrinding necessary on a roll, after its surface has been destroyed, will vary considerably, but the average decrease in diameter per grinding will run from .008 inch to .011 inch. A roll is reground as often as necessary, until its diameter has been reduced to a point where its surface hardness is no longer sufficient for satisfactory results in cold rolling. The surface hardness of our rolls as received will run usually from 100 to 105 scleroscope. When the roll has been reground until its surface hardness is below 90 scleroscope, we find they do not give good service, except on soft material. When rolls get down to about 85 scleroscope, they are set aside for rehardening or cutting down to a smaller size roll. On the average we find that rolls need to be rehardened after they have been reduced about one-half inch in diameter.

The problem of improved quality in cold rolls consists of obtaining a surface which will give longer service before they need to be reground, or the development of a steel which can be safely hardened to a greater depth,

so that a greater number of grindings can be taken on a roll before it needs rehardening. The roll users can be of great service to the roll makers in the solution of the problem, by keeping accurate records of the life of each roll. This record should include the amount, size and kind of material rolled between grindings, the number of grindings and the final diameter of the roll when it is set aside for rehardening.

The Chairman (Mr. W. A. Rogers): The next paper is The Cleaning of Blast Furnace Gas, by Mr. G. M. Hohl, Bethlehem Steel Company, Bethlehem, Pa.

THE CLEANING OF BLAST FURNACE GAS

G. M. Hohl

Bethlehem Steel Company, Bethlehem, Pa.

During the entire period of the development of the blast furnace to the size and capacities of the furnace of today, more attention was paid to the design and construction of the stack than to the auxiliary equipment.

The constant demand for higher blast temperature began a revolution in stove design and brought about the change in checker opening size from 9x4 inches to 4x4 inches or even smaller. For stoves with small checker opening to remain in service, clean gas is required; and this was one of the first causes for the demand for clean gas. The economical side, of burning gas correctly, and the studies and improvements that have resulted in obtaining the maximum efficiency from the gas, have nearly all come in this country during the past fifteen years. The higher costs of fuel and labor and the sharpness of competition have forced managers to pay more attention to their plant heat balances, and the results of constant efforts to stop heat leaks are now apparent at most plants.

The value of clean gas can be appreciated only by those who have operated with both dirty and clean gas. The most noticeable savings are:

1—Reduction in the cost of cleaning and repairing stoves.

2—Higher blast temperatures, resulting in lowered coke practice, increased output and cheaper pig iron.

3—Saving in gas used by stoves, leaving more gas available for boiler and gas engine use.

The heat economies possible by utilizing the sensible heat of the gas leaving the dust catcher have long been recognized. According to Richards and Johnston, about 11 to 12 per cent. of the total heat generated within the furnace leaves as sensible heat in the top gases. More recently published calculations of Messrs. Joseph, Royster and Kinney, using data obtained from fourteen furnaces, show that the top gases carry out 10 to 12 per cent. of the total furnace heat.

The problem of which style of gas washer or cleaner shall be used involves many factors besides the question of heat saving. The initial cost, the cost of operating, the recovery and disposal of the dust, the degree of cleanliness desired in the gas, the equipment already installed, the character of the raw materials used, and the location of the plant, all of these vary. The cost sheet, as usual, is the final judge, and it is believed that the apparently large number of different washers and cleaners in use today may be accepted as representative of the best practice at various plants to fit local conditions.

Preliminary Cleaning of Blast Furnace Gas

The preliminary cleaning of the gas is always done by one or two dust catchers, either alone or with a whirler of some type.

The original dust catcher was simply an enlargement in the downcomer to allow the heavier particles of dust to settle. The average dust catcher today is about 25 feet in diameter and 30 feet high. Some are larger, and one with 40 feet diameter is in use.

All preliminary cleaning is the application of one or more of the three basic principles of removing dust from gas, i.e., changing the direction of the gas, reducing the velocity, or the separation of dust by gravity or centrifugal force. There are several well known types of whirlers in use, embodying these principles, such as the Brassert-Witting, the Kennedy and the Dyblie.

Large dust catchers, properly designed, can remove

about 90 per cent. of the dust from the entering gas, reducing the dust content of the exit gas to 2.75 to 5.00 gr. per cu. ft. The work of the primary washer or cleaner can be greatly lightened, by using the dust catcher to the best advantage.

After the preliminary cleaning, the gas is generally further cleaned by either a wet or dry cleaner. This is called the primary cleaner. At some plants all the gas from the furnaces is primary cleaned, at others only the gas for stove use. The gas for stoves should contain not more than .2 gr. of dust per cu. ft. For gas engine use, the gas should not have more than .015 gr. per cu. ft. and must pass through a scrubber or secondary cleaner.

Kinds of Cleaners

There are but two main methods to clean gas, namely, a wet and a dry process. These may be subdivided as follows:

A—WET WASHERS

1—The impact type of washer, such as the Mullen and the Steese and Ford.

2—The counterflow type, such as the Brassert and the Steinbart.

3—The rotary type, such as the Theisen and the Feld.

B—DRY CLEANERS

1—The filtering type, best represented by the Kling-Weidlein and the Halberg-Beth.

2—The change of direction type, such as the By-Product Recoveries Company.

3—The electrical type, or Cottrell Process.

Wet Washers

A—IMPACT TYPE. The best known of this type of wet washer are the Mullen and the Steese and Ford, shown in Fig. 1.

In the Steese and Ford washer, the lower third is full of water, kept at a constant level by an overflow. The

gas enters at the end, and striking the surface of the water, is reflected back, and passes out through the main in the center. This is repeated three times.

In the Mullen washer, Fig. 2, the gas enters at the top and passing through the tubes C, strikes the surface of the water. The light dust is carried away on the surface, while the heavier particles sink below the surface and are flushed off through the bell valve at the bottom.

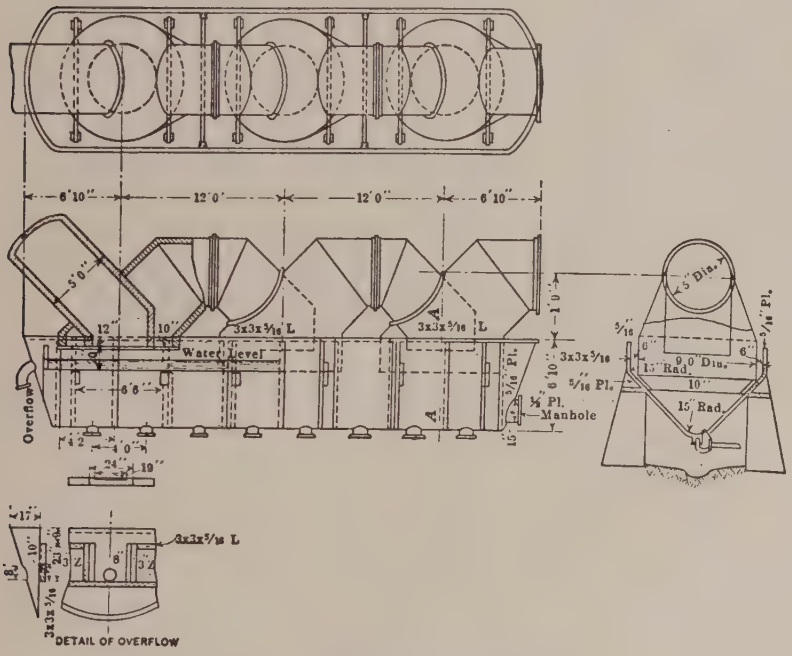


Fig. 1—Steese-Ford gas washer.

Present day necessities at some plants demand cleaner gas than can be furnished by impact type washers.

B—THE COUNTERFLOW TYPE. This is the type of washer generally used for primary cleaning. It consists primarily of a steel shell 10 to 15 feet in diameter and about 80 feet high, with the gas entering at the bottom and leaving at the top. Water is sprayed from the top,

or through nozzles in the side, and the gas, passing through the spray, is cooled and washed.

With the exception of the Steinbart, all of these washers contain horizontal screens, grids or hurdles, of

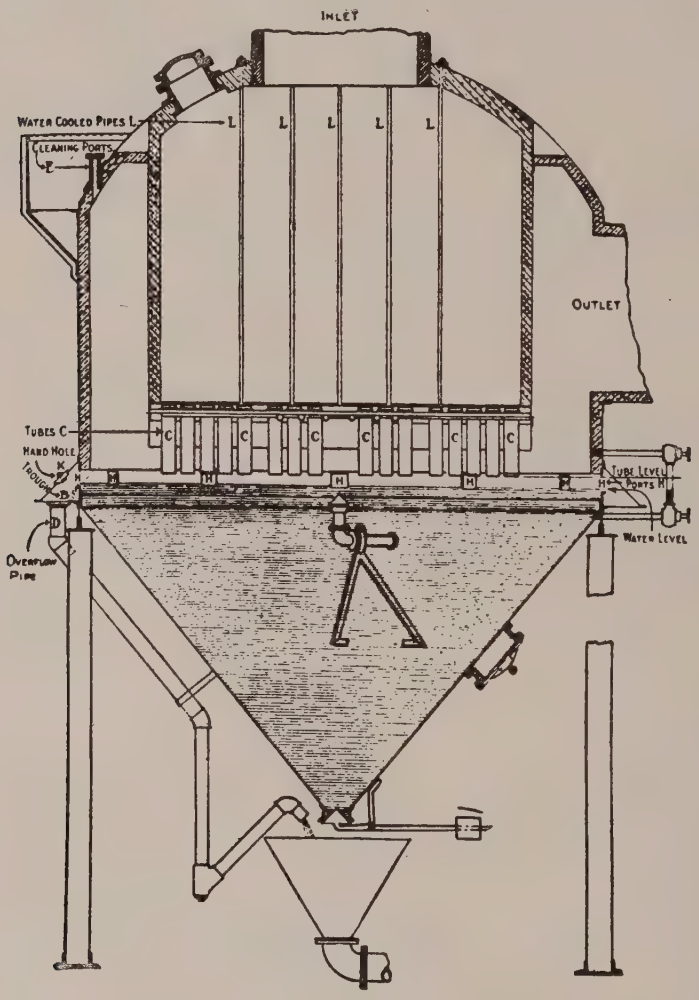


Fig. 2—Mullen gas washer.

steel or wood, to break up the water into a fine spray and to force more surface contact between the dust and water. The success of these washers depends upon obtaining the proper distribution of the water and the ex-

tent to which the dust particles can be brought into intimate contact with the water particles.

Zschocke Washer—The Zschocke tower was one of the first wet washers introduced into this country, being developed in Germany.

The water was introduced at the top through ordinary nozzles, and dripped down through the wooden hurdles. A fairly intimate contact is obtained in this way.

This washer is excellent for cooling the gas, and it lowers the dust content to about .3 gr. per cu. ft., but it requires a large volume of water.

Steinbart Washer—This washer is in use at many plants today. It consists of a steel tower about 15 feet in diameter and 80 feet high. The water is introduced through a nozzle at the top, the nozzle being rotated by a motor geared to it. A cross section of this washer is shown in Fig. 3. The tower contains but one grid at the top. The nozzle is designed to distribute the water uniformly over the entire area, and is shown in Fig. 3a.

Generally three such towers are used in parallel to clean all the gas from a 500-ton furnace. Each tower requires 750,000 gallons of water per twenty-four hours. The water consumption is about 33 gallons per 1,000 cu. ft. of gas cleaned. The dust content is reduced from 2 to 3 gr. per cu. ft. to .20 to .25 gr.

Some of the newer washers use a nozzle that throws one heavy spray per revolution, in place of the two sprays, 180° apart, of the older type.

The speed of the nozzles has also been decreased from 120 R. P. M. to 60 R. P. M. The use of this nozzle with its heavier shower reduces the dust content of the exit gas to less than .20 gr. per cu. ft.

Brassert Washer—This is one of the best known of all the wet washers. There are nearly one hundred of these in service in this country.

The general rule followed by the designers is to use a 10 foot washer for a 400-ton furnace for the stove gas only, and a 12 foot washer for a 600-ton furnace for

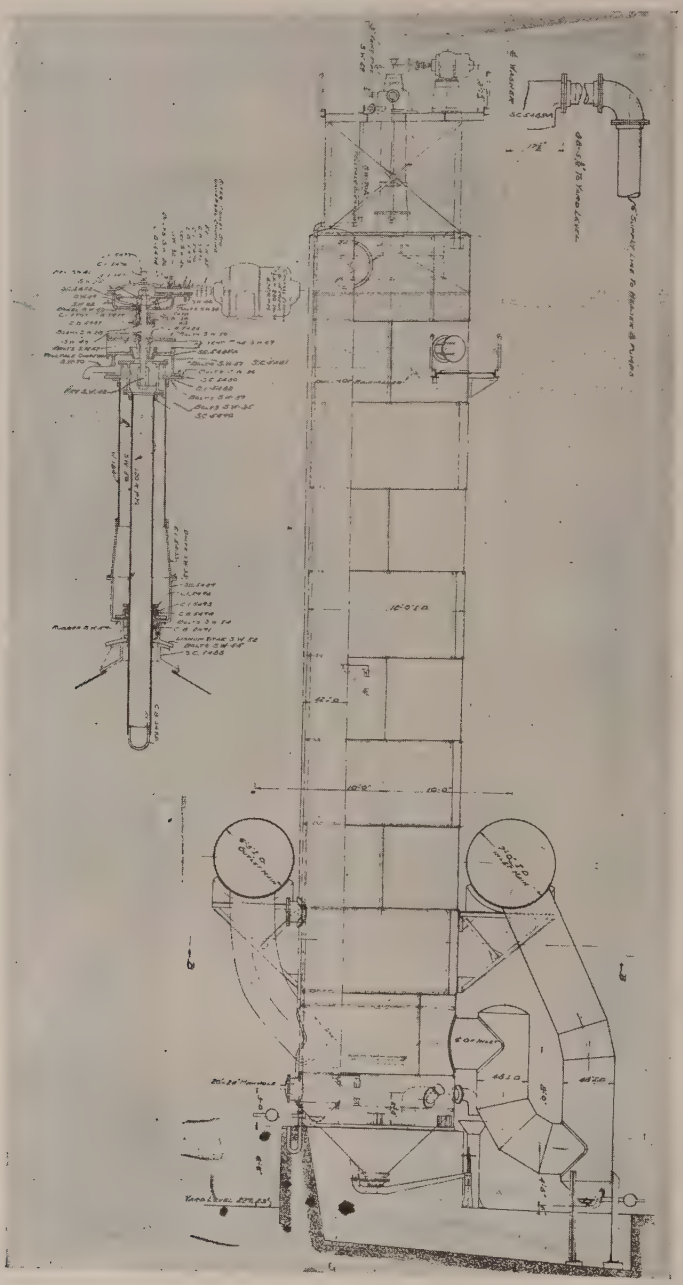


Fig. 3—Steinbart gas washer.

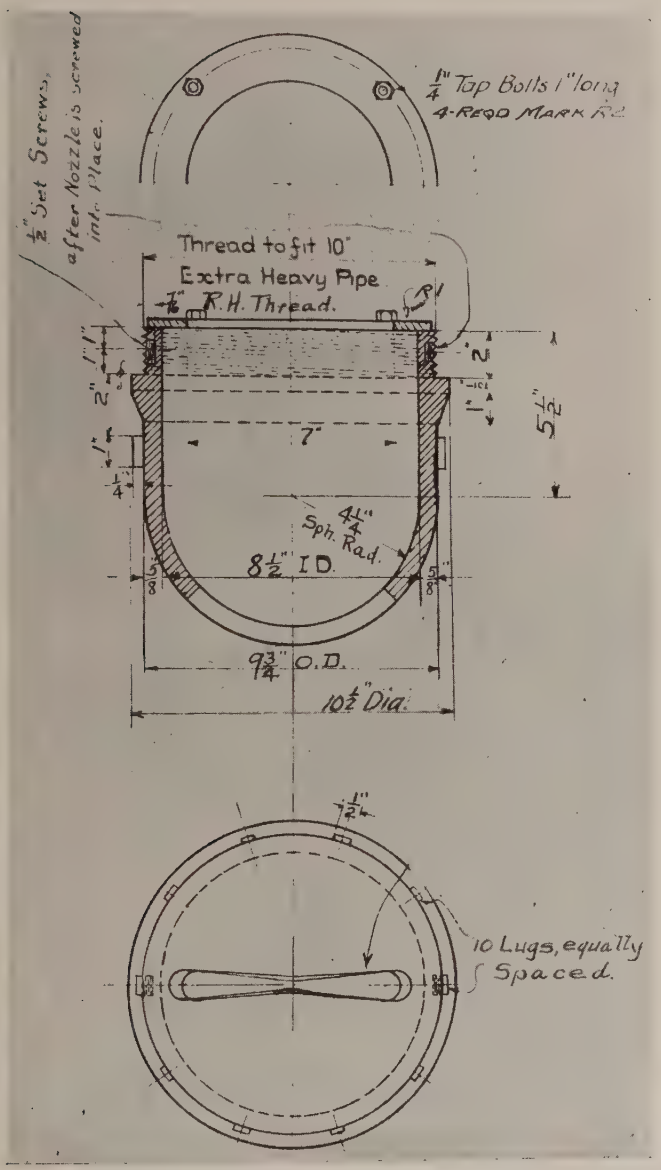


Fig. 3a—Sprinkling nozzle, Steinbart gas washer.

the stove gas only. Most of the installations are of the standard 15 foot diameter, suitable for washing up to 60,000 cu. ft. of gas per minute, thus handling all the gas from the furnace. This size uses 1,500 gallons of water per minute at a pressure of 60 pounds at the base of the washer. The water consumption is at the rate of 25 gallons per 1,000 cu. ft. of gas. This in practice has been found ample to reduce the dust content of the gas from 10 gr. per cu. ft. to about .25 gr. per cu. ft. on leaving the washer. Both measurements refer to standard conditions.

A cross section of a Brassert tower and the details of the wooden hurdles are shown in Fig. 4.

In the Brassert tower the dirty gas enters the bottom, meets a heavy shower of water discharged from the distributing apron and becomes thoroughly saturated with moisture. Turning upward, it is forced by the apron to distribute uniformly in entering the hurdles. The hurdle banks are superimposed in two or three banks with a short space between each bank. These hurdles are offset in each element to open vertical channelling. The hurdles and open spaces are designed to give alternation of rain and contact surface. They retard the descent of water through the washer, give an increased time of contact and increase heat interchange and water economy.

There have been some changes in the Brassert washer in recent years, brought about as a result of experience with the early type. The perforated distributing trays have been omitted in the newer type, the gas distributing cone has been added, and the arrangement of the internal water piping and spray nozzles has been changed.

This change in the arrangement of the spray nozzles, which was the invention of, and is patented by, Mr. Walther Mathesius of the Illinois Steel Company, has brought about a much more uniform distribution of the water over the woodwork and eliminates the possibility of the gas channelling between the spray nozzles. This spray nozzle arrangement has made it possible to bring

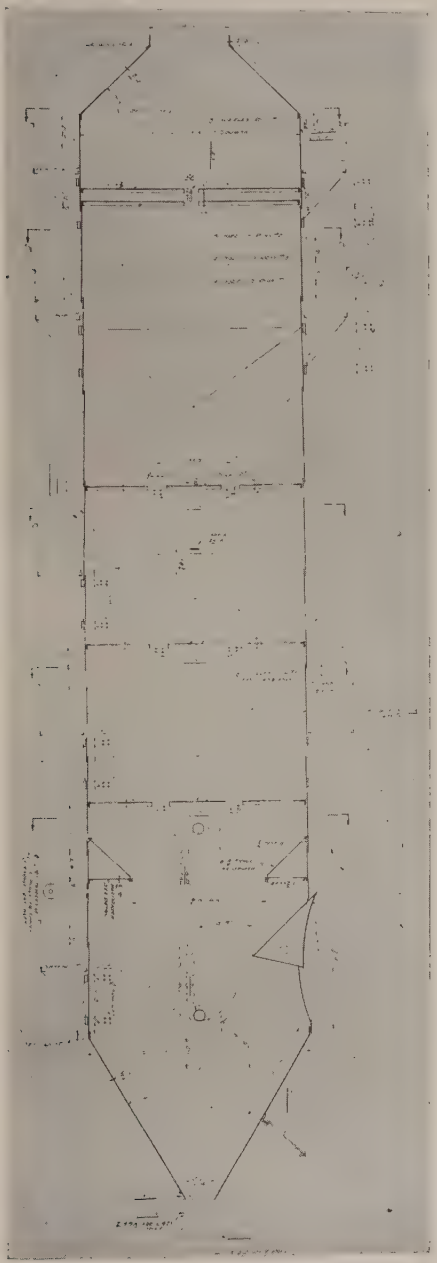


Fig. 4—Brassert-Bacon gas washer.

the outgoing gas within 4° F. of the incoming water temperature, regardless of the incoming gas temperature. The elaborate dryer system used in connection with the early type is not now used, as substantially the same results are obtained in a simple water seal type of dryer.

The cost of operation is very low, one set of two or three washers requiring one man per turn at the pump house, and, using bosh water, the cost should not be over 1 cent per ton of iron to wash all the gas from the furnace.

Other Types—There are other designs of counterflow wet washers in use, such as the Diehl and the Geisman. A number of plants use wet washers of their own design based on the same general principles as the Brassert and the Steinbart.

The Feld washer, which is a rotary vertical scrubber, has been used in gas plants for many years. One installation is being built to clean blast furnace gas at the present time.

Fine Cleaners

These are used only where the gas is to be used in gas engines. For this purpose the dust content of the gas should be less than .015 gr. per cu. ft. To obtain this degree of cleanliness, the gas must be scrubbed, and the most intimate mixture of gas and water must take place.

Theisen Washer—The Theisen is universally used to wash the gas for fine cleaning. It consists of a horizontal casing, slightly tapered toward the outlet end, lined with a wire netting. Within this a drum revolves at a high speed, on the drum are numerous fine blades set at oblique angles to the axis of rotation. The gas is drawn in at one end and expelled at the other end. Water is admitted at the side of the casing and is connected with a fine spray. The special arrangement of the blades causes the spray to flow in the opposite direction to the gas. A cross section of the Theisen washer is shown in Fig. 5.

These washers have proved most satisfactory for fine

gas cleaning. The water consumption is low, but the cost for power is high; as a 150 to 250 horse-power motor is required to rotate the internal drum. With the exception of the power, cost of operation is low. The simplicity of the construction, and the clean gas obtained, has made their adoption for fine gas cleaning almost universal.

At one plant, where the gas leaving the furnace contains a large amount of zinc, Theisen scrubbers are used to clean the gas for the stoves. Aside from the trouble caused by the deposition of the zinc, which would occur in any washer, it has been very satisfactory for this work.

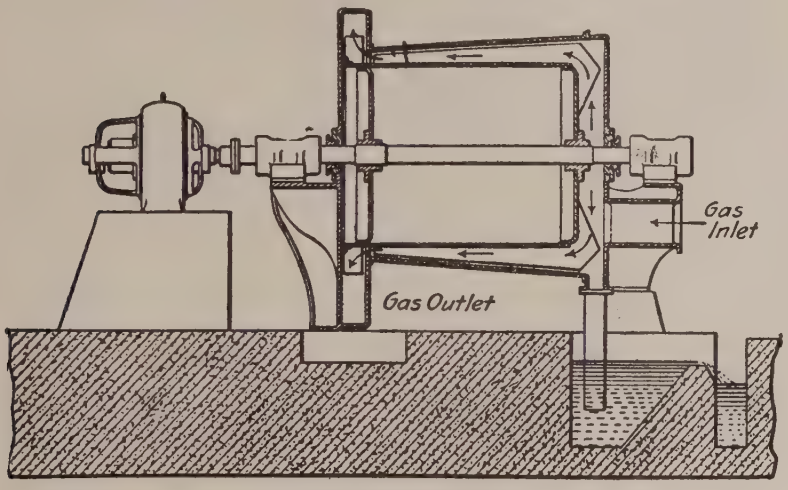


Fig. 5—Theisen gas washer.

The Theisen scrubber acts as a fan in raising the gas pressure from 4 to 7 inches H_2O. In many cases this is sufficient pressure to send the gas to the power house, without the addition of booster fans, so the power consumption is not really all expended on the washing alone.

A scrubber handling 15,000 cu. ft. of gas per minute uses about 125 gallons of water per minute.

Dry Cleaners

Kling-Weidlein—One of the first dry cleaners that reduced the dust content to the point desired was the Kling-Weidlein. This consists primarily of a series of

chambers in which the gas is filtered by passing through a mat, filled with steel wool. As the mats become full of dust, the flow of gas is shut off momentarily and the mat is shaken, the dust falling into a hopper below, from which it is periodically removed. An automatic valve arrangement shuts off the gas from one chamber, after another, during the shaking process. The general arrangement of the Kling-Weidlein is shown in Fig. 6.

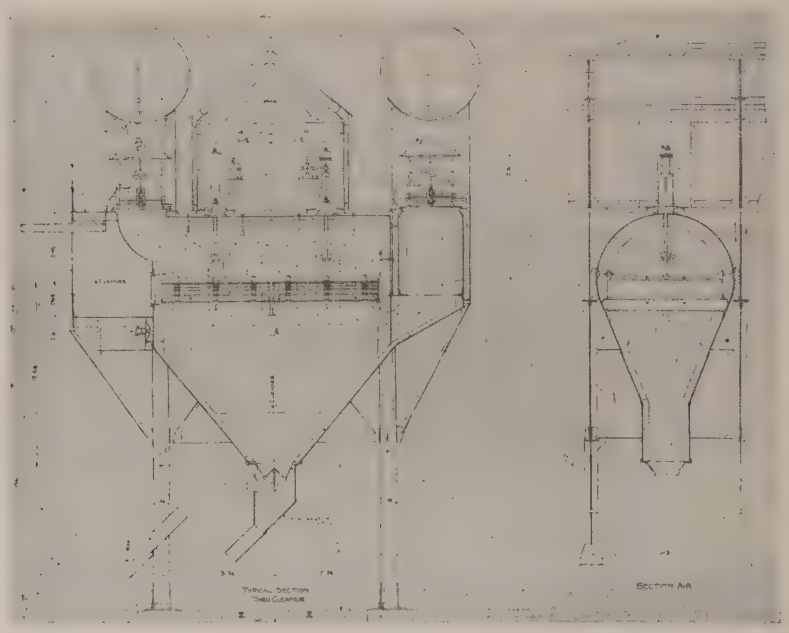


Fig. 6—Kling-Weidlein gas cleaner.

The essential part of the cleaner is the mat. Originally several different grades of steel wool were used. The practice is now to use but one or two grades.

There are a number of these cleaners installed at present, varying from 5 to 9 units per cleaner. These clean all the gas at some plants, and the gas for the stoves only, at others. The dust content of the exit gas ranges from .25 gr. to .5 gr. per cu. ft. This can be regulated somewhat by the degree of fineness of the mats.

The average drop in temperature through the cleaner is about 50° F., and the drop in pressure about 1½ inches H_2O.

Other Types—As with wet washers, a number of modifications of the general type of dry cleaner have been built at several plants. These are based on the three principles previously mentioned in connection with dust catchers and preliminary cleaning. The Breiney cleaner at Wharton, N. J., uses the two bars inside the dust catcher with a tangential flow of gas. No data are available on the dust content of the exit gas, but, from appearances, and the condition of the stoves, it should be below .6 gr. per cu. ft.

A change of direction type of dry cleaner has recently been introduced by the By-Products Recoveries Com-

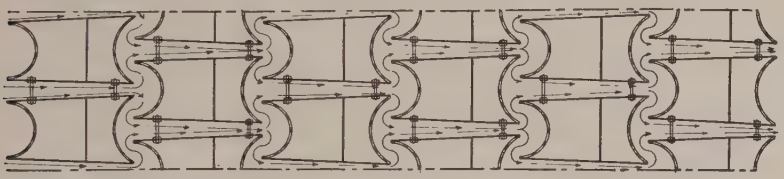


Fig. 7—Diagrammatic plan of gas movement through By-Products Recoveries dry gas cleaner.

pany. A diagrammatic plan of the gas movement through the machine is shown in Fig. 7. None of these have been applied to blast furnace gas at present, but the process is being used successfully by other industries.

The Halberg-Beth system of filtering through canvas bags has been used for dry cleaning in Europe for some time. There are no installations in this country.

Electrical Dry Cleaner—The Cottrell treater, for the electrical cleaning of blast furnace gas, consists of a steel shell about 9 feet in diameter filled with 6 inch pipes 10 feet long. Eight of these units are required to clean all the gas from a 500-ton furnace. Each unit contains 90 pipes, and has a capacity of 11,000 cu. ft. of gas per minute at main conditions. The velocity of the gas through the treater is 10 feet per second.

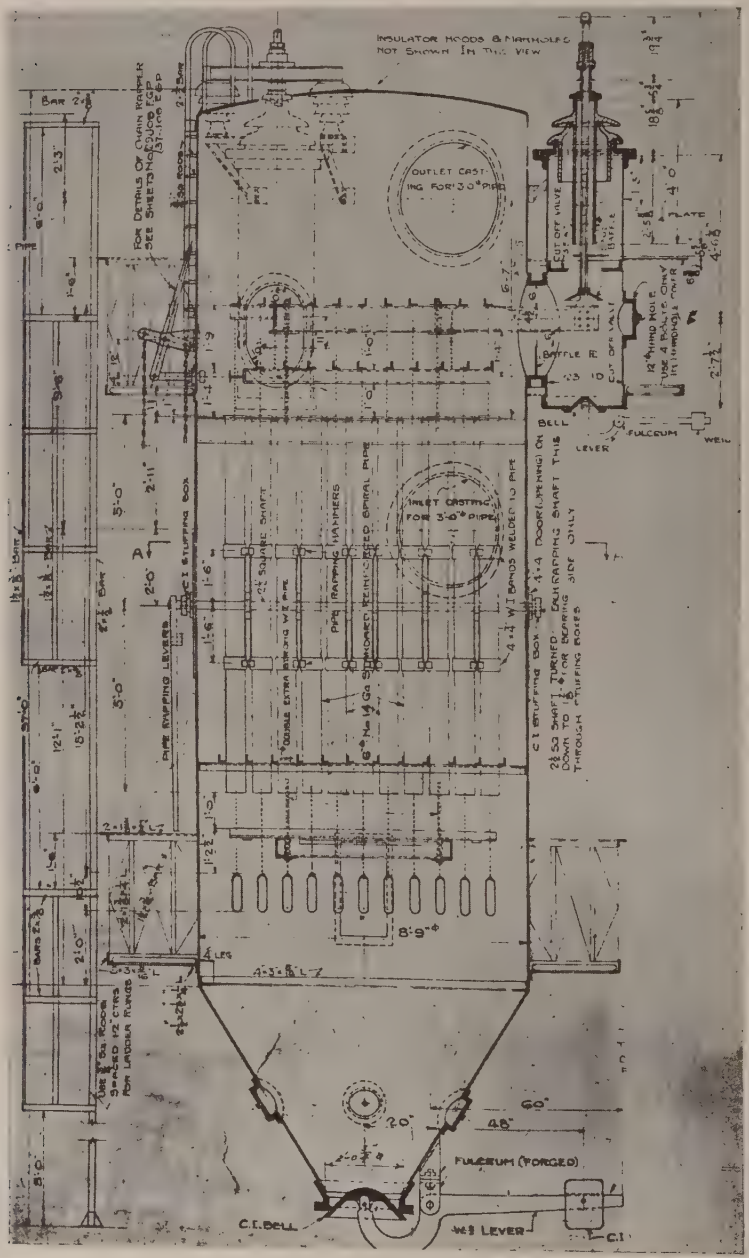


Fig. 8—Cottrell electrical precipitator.

A wire electrode is suspended throughout the length of each pipe. Unidirectional current at 35,000 to 40,000 volts is passed through the wires.

A full description of the construction and operation of the most recently built electric cleaner is given in an article by Mr. N. H. Gellert in the *Iron Age,* February 7, 1924, and I am indebted to him for the drawing, Fig. 8, and the data here given.

The dirty gas enters the main shell at the top, and enters the pipes at the bottom. The dust particles, entering the field of the discharge from the wire, become charged and are drawn to the pipe wall, where they are held.

Periodically the pipes must be cleaned and an automatic device shuts off the current and the flow of gas, and the pipes are rapped by a set of small hammers, the dust falling into the hopper below.

The electrical cleaner has passed the experimental stage and undoubtedly will become more popular. The mechanical and electrical difficulties that were encountered in the earlier installations have been overcome, and as now built, it is a really workable installation.

Heat Saved by Using Dry Cleaned Gas

From the standpoint of heat economy alone, dry cleaning the gas is superior to wet washing. The sensible heat of the gas leaving the furnace is an item well worth saving.

Due to the cooling, the cleaning of the gas by a wet washer results in reducing the moisture content of the gas. The top gas from a furnace using Lake ores contains from 25 to 40 grains of moisture per cu. ft. (at standard conditions). If the stock is wetted in the skip, as is the practice at many plants, the moisture content is higher. This same gas after wet washing is completely saturated at the temperature of leaving the washer. This seldom exceeds 90° F., in which case the moisture content is only 14.9 gr. per cu. ft.

As pointed out by Johnston, it is an error to include the latent heat of vaporization of moisture, as it cannot be available under any circumstances. Comparing the sensible heat of gas at 350° F. and 28 grs. moisture per cu. ft. with the sensible heat of the same gas cooled to and saturated at 75° F. shows that the hot gas contains about 5.5 B. T. U. per cu. ft. more than the washed gas. Thus, assuming 140,000 cu. ft. of gas per ton of pig, equals 770,000 B. T. U. per ton of pig, or the equivalent of 52 pounds of 14,500 B. T. U. coal. On a 500-ton furnace, this is equivalent to the heat in 11.5 tons of coal per day.

This saving is utilized by reducing the volume of gas required for the stoves and leaving more available for boiler use. The temperature of combustion of the gas is increased from 60° to 90° F.

Table A shows the percentage increase of the total heat available of blast furnace gas, which is the latent heat of combustion plus the sensible heat of the gas, and

TABLE A.—PERCENTAGE OF HEAT SAVED TO TOTAL HEAT, DRY CLEANING VS. WET WASHING.

Temp. of Gas	100°	200°	300°	400°	500°	600°	700°	800°	900°	1000°
1	.2	2.5	4.8	7.1	9.5	11.9	14.4	17.0	19.5	22.2
2	.2	2.4	4.6	6.8	9.1	11.5	13.9	16.4	18.8	21.3
3	.2	2.3	4.4	6.6	8.8	11.1	13.4	15.7	18.1	20.5
4	.2	2.2	4.3	6.4	8.5	10.6	12.9	15.1	17.4	19.7
5	.19	2.1	4.1	6.1	8.2	10.3	12.4	14.5	16.8	19.0
6	.19	2.1	4.0	5.9	7.9	9.9	12.0	14.1	16.2	18.3
7	.18	2.0	3.9	5.7	7.7	9.6	11.6	13.6	15.6	17.7
8	.18	1.9	3.7	5.5	7.4	9.3	11.2	13.1	15.1	17.1
9	.17	1.9	3.6	5.4	7.2	9.0	10.8	12.7	14.6	16.6

TABLE B.—ANALYSES OF GASES IN TABLE A.

Gas	CO	CO_2	H_2	N_2
1	25.0	15.0	2.4	57.6
2	26.0	14.0	2.4	57.6
3	27.0	13.0	2.4	57.6
4	28.0	12.0	2.4	57.6
5	29.0	11.0	2.4	57.6
6	30.0	10.0	2.4	57.6
7	31.0	9.0	2.4	57.6
8	32.0	8.0	2.4	57.6
9	33.0	7.0	2.4	57.6

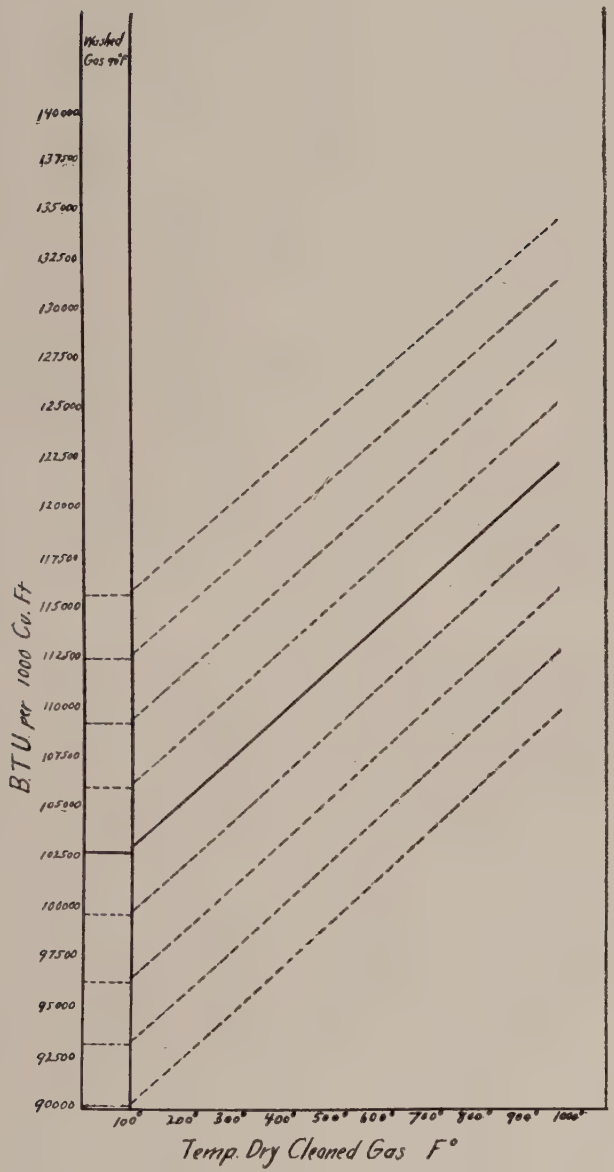


Fig. 9—Heat content of dry cleaned gas at various temperatures.

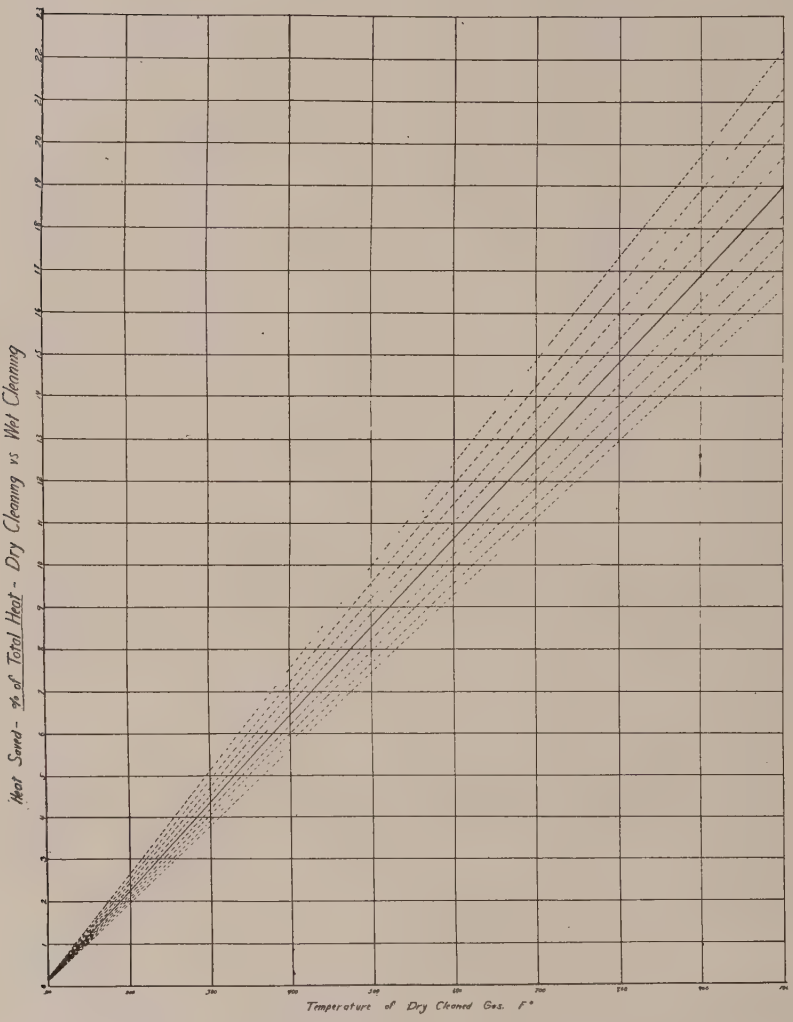


Fig. 10—Heat saved for various temperatures of dry cleaned gas.

the moisture as steam at various temperatures, compared with cool washed gas at 90° F. The higher the top temperature, the greater will be the percentage of sensible heat saved.

There are some plants using a dry burden of magnetite and sinter where the moisture content of the top gas is below 10 gr. In this case, wet cooling has the double disadvantage of adding moisture to, as well as removing heat from, the gas.

Operation of Various Types

There are more data available on the performance of wet washers than of the dry cleaners. In general the best wet washer, cleaning all the gas from a furnace, lowers the dust content to .15 to .25 gr. per cu. ft., and cools the gas to from 4° F. to 10° F. above the temperature of the entering water. The water used is from 30 to 35 gallons per 1,000 cu. ft. of gas cleaned, and the power consumption .04 K. W. per 1,000 cu. ft. of gas cleaned.

In the dry cleaner, the power consumption is low and is only needed by the rapping or shaking device. The Cottrell treater uses about .1 watt per 1,000 cu. ft. of gas cleaned.

The labor cost of operating all cleaners is very nearly the same, one attendant per turn being required for each unit, or set of units.

The dust recovered from dry cleaners is very fine, over 90 per cent. passing through a 100 mesh screen.

Flue Dust as Washer Sludge

The flue dust in the outgoing water from wet washers represents a loss of 10 to 15 tons of 45 per cent. iron bearing material every day. The early attempts to recover this were small basins through which the dirty water passed, allowing the dust to settle to the bottom. The sludge was periodically removed with a grab bucket or an overhead crane. The size of the settling basin was

increased, as the recovery proved profitable, and at one plant eight of these basins each 120 feet long by 40 feet wide are used.

The latest development in sludge recovery has been the adaption of the Dorr thickener to this work. It has proved very satisfactory, over 95 per cent. of the dust being recovered. The sludge from the thickener is pumped to the furnace skip, and dumped back into the furnace. The danger of stream pollution is thus avoided, in addition to the value of the dust recovered.

This recovery of sludge is by no means universal, as the washer water at many plants is still thrown away.

The dust recovered from a dry cleaner can either be charged back into the furnace or sintered.

There probably never will be an agreement among furnace men as to the advisability of recharging flue dust. At some plants large amounts are used, with no bad results, so it is claimed. At others none is used. Whether it can be charged or not, probably depends upon the ore mixture, the quality of the coke, the design of the stack, and the quality of the iron that must be made.

Cleaner dust, thoroughly wetted, is the same as washer sludge, so, if the material is to be recharged, there is nothing to choose between the two types. If the dust is to be sintered, however, the dry cleaner has the advantage of delivering the dust dry ready for use.

General Considerations

In choosing the type of washer or cleaner for a plant, the existing equipment and the raw materials used must be taken into account.

The size of the stove checkers should determine to what degree the gas should be cleaned. There is not much to be gained in cleaning the gas to .2 gr. per cu. ft., if the stoves all have 9x9 inch checkers and dirtier gas could be used.

There is not much difference in the price of any of the well known primary washers and cleaners. The operat-

ing cost of the dry cleaner is invariably lower than for washers, as less power and no water is required.

The ground space required for a dry cleaner is much more than for a washer. Some plants would have difficulty in finding room for a full size dry cleaner. Settling basins and Dorr thickeners also require considerable ground space, but these can be placed at some distance from the furnace and washer.

On the basis of heat economy, the dry cleaner has the advantage, provided there is a market for the gas saved and the extra steam produced. This advantage increases with the cost of fuel at the plant.

I wish to acknowledge the data and drawings furnished by Mr. A. T. Keller of the Bethlehem Steel Company, and by Freyn, Brassert & Company, and A. G. McKee & Company.

The Chairman (Mr. W. A. Rogers): The first discussion of the paper on The Cleaning of Blast Furnace Gas is by Mr. J. C. Barrett, Blast Furnace Superintendent, Ohio Works, Carnegie Steel Company, Youngstown, Ohio.

Discussion by J. C. Barrett

Blast Furnace Superintendent, Ohio Works, Carnegie Steel Company

In connection with the utilization of escaping gases from a blast furnace in the making of pig iron, it would be well to review some of its history. There was a period not long ago when these gases escaped to the air as waste. In the year 1837, eighty-seven years ago, Faber du Faur is credited with the first use of these escaping gases. A few years before, in 1828, Neilson came to the conclusion that heating the air before it reached the fuel might be useful, with the result that the hot blast stove was developed, and, later, the utilization of the waste gases in heating the Neilson stove which was made of iron pipe. These developments mark a great step in conservation.

The most marked improvement was in the use of the fire brick stove and its development, although with dirty

gas. The gas not used for heating the stoves was used for producing steam or power.

All this turned the thoughts of the iron smelter and engineer toward better production and lower costs.

The escaping gas from the blast furnace thus became a by-product but it must be cleaned to make its use most efficient.

In cleaning this gas we can recover a material (sludge) which adds to the more efficient use of the raw iron bearing material, if the furnace man will not waste it. Saving this is real conservation.

When we consider the art of making pig iron with its eighty-seven years of development, from the day of Faur and Neilson to the present time, with the losses that have been allowed to exist, we are hardly pardonable. However, the day of clean gas has arrived and Mr. Hohl has described the only practical methods and apparatus available, yet the apparatus may be made more efficient by further development.

The most economical use of blast furnace gas has been developed in the last twenty-five years. A great deal of time, thought and money has been expended to produce a gas of the required cleanliness. To produce this desired condition, we have saved in the available heat, recovered the raw iron bearing material that was wasted in the gas and water, saved in fuel and made gas more useful for power and steam, all of which reaches the desired end—true conservation of resources—and the concern or plant which installs the properly designed blast furnace gas cleaning apparatus will have but little wasted. Mr. Hohl has enumerated the most noticeable savings.

In cleaning gas the first essential is a good dust catcher, where the larger particles of dust are received and settled out of the gas current. This apparatus is open for improvement; it should be large and if possible the dust should be conveyed into a part of the dust catcher which would let it rest and not be stirred up

again. One of the latest improved dust catchers is that developed by Mr. Brown of Lorain. Ninety per cent. of the dust entering the dust catcher is arrested, to which Mr. Hohl calls our attention. This is rather high for a furnace running on Lake ores.

Following the dust catcher, there are two methods of cleaning the gas, the wet and dry methods. The primary wet method is the one which is most widely used, and it necessitates a great deal of attention to take care of the gas mains and gas burners because of the sludge which is entrained, and for this reason it produces a gas which is not ideal. It is a gas containing .25 to .50 grains of dust per cubic foot, and it has lost to the water a sensible heat of from 300° to 500° F. which is valuable, if it could be retained.

The dry method of cleaning produces a gas as clean as that made by the wet method without the sludge and loss of sensible heat, but it carries all of the water that was introduced into the furnace.

The dry cleaned gas has a small percentage of dust, which floats in the gas and is light, and, altogether, approximately the same percentage is in the wet cleaned gas, where it travels as a sludge and is heavy. This gives a difference in our experience which must not be overlooked in its application to use in boilers and stoves. The dry cleaned gas gives a coating in its use which collects on boiler tubes and is easily blown off, while the wet cleaned gas gives a coating on the boiler tubes which is hard to get off. The dry cleaned gas in the stoves carries this fine floating dust to and through the checkers, where it lodges on the top and is of a soft spongy nature and is easily blown off with an air or steam jet. The dirt from the wet cleaned gas gathers mostly in the bottom of the combustion chamber, and it gathers on the top of the checkers much slower, which is naturally to be expected on account of the heavy sludge which does not float in the gas. This indicates that checkers for dry cleaned gas should not be under a 4¾″ opening.

The following tabulations show a comparison of heat units required to raise gas to stack temperature in the use of wet and dry cleaned gas; also the saving due to the use of dry cleaned gas:

Comparison of Heat Units Required to Raise Gas to Stack Temperature

DRY CLEANING

Gas temperature...400° F.

Moisture.....50 grains per cubic foot of gas

$\frac{50}{7000} = .00715$ pound per cubic foot

.0505 pound per cubic foot of water vapor

$\frac{.00715}{.0505} = 14.1\%$ of volume is moisture

Stack temperature assumed to be 500° F.

Gas	Per Cent. Volume	B. T. U. per Cubic Foot 400° to 500° F.	B. T. U. per Cubic Foot of Dry Gas	
H_2O (vapor).....	14.1	2.3	.324	
CO_2.....	12.0	2.9	.348	
H.....	3.0	2.0	.06	=2.108
CO.....	25.2	2.0	.504	
N.....	59.8	2.0	1.196	
Total B. T. U. per cubic foot dry gas.....			2.432	

WET WASHING

Gas temperature.....75° F.

Gas saturated with moisture at 75° has 9.5 grains per cubic foot

$\frac{9.5}{7000} = .00135$ pound per cubic foot

$\frac{.00135}{.0505} = 2.7\%$ moisture

Gas	Per Cent. Volume	B. T. U. per Cubic Foot 75° to 500° F.	B. T. U. per Cubic Foot of Dry Gas	
H_2O (vapor).....	2.7	9.4	.0254	
CO_2.....	12.0	11.0	1.3200	
H.....	3.0	7.8	.232	=8.176
CO.....	25.2	7.8	1.964	
N.....	59.8	7.8	4.660	
Total B. T. U. per cubic foot dry gas.....			8.2014	

	B. T. U. Required to Heat Gas to Stack Temperature of 500° F.	
	Moisture B. T. U.	Dry Gas B. T. U.
Wet cleaning.....	.025	8.176
Dry cleaning.....	.324	2.108
Difference.....	.299	6.068

With 90 B. T. U. gas .299 equals 0.33% of heat in gas
With 90 B. T. U. gas 6.068 equals 6.75% of heat in gas

The above shows that the dry cleaning process requires 0.33% of the heat in the gas more than the wet cleaning process to raise the temperature of the moisture contained in the gas to a stack temperature of 500° F. Also that the dry cleaning process requires 6.75% of the heat in the gas less than the wet cleaning process to raise the temperature of the dry gases to a stack temperature of 500° F. The difference of 6.42% is that saved by the dry cleaning process.

SAVING DUE TO USE OF DRY CLEANED GAS

	Saving of Dry Cleaned Gas Over	
	Wet Washing	Rough Gas
Saving due to sensible heat—400° gas, 500° stack	$23,800	
Saving due to increased stove efficiency, 5% dry over wet cleaned	5,920	$5,920
*Saving of $.1591 per ton of iron—wet cleaned over rough	.....	30,000
Coal saving due to increased boiler efficiency, 10%	20,280	20,280
Value of extra flue dust recovered at $3.00 per ton	7,630	15,400
Saving in power (repumping)	6,845	.....
Saving in labor, gas washer men	2,150	.....
Saving in steam cranes, cleaning sumps	930	.....
Saving in cleaning gas mains and stoves	323	968
Saving in cleaning boilers (blowing tubes)	1,200	2,538
Saving in cleaning boilers (removing dust from settings)	.....	1,840
Saving in heating up stoves after cleaning	.....	894
Total	$69,078	$77,840

*American Institute of Mining Engineers, October, 1913, A. N. Diehl:—Saving of $.1591 per ton iron produced with wet cleaned gas over rough gas due to increased production and increased stove capacity, and decreased limestone consumption. 190,000 tons per year x $.1591 equals $30,000 per year.

We have followed very closely the amount of dust that is caught in a dry cleaner and wet washer settling basin or Dorr thickener, and in the use of Lake ores the blast furnace operator who does not use good gas washers or dry cleaners, but uses the gas raw, or the operator who has a washer and does not collect the dust in a good settling basin, but allows it to go to the river or lake, is losing one-third of all the dust the blast furnace produces. The following tabulation shows a comparison of the dust recovered by means of the Dorr thickener, dry gas cleaner and settling basins:

COMPARISON OF DUST RECOVERED

	By Means of		
	Dorr Thickener	Dry Gas Cleaner	Settling Basins
Gas through washers per minute	59,200	52,000	52,000
Water through washer per minute, gallons	2,570	None	1,678
Water per 1,000 cubic feet gas at washers	43.2	None	31
Flue dust per gallon in washer discharge water, grains	158.0	None	134
Flue dust per cubic foot gas removed in washers, grains	6.82	4.38	4.31
Flue dust removed by washers per day, pounds	83,900	47,000	46,100
Flue dust removed by washers per day, tons	37.4	20.95	20.56
Total flue dust removed by dust catcher per day, tons	64.0	33.35	32.00
Total flue dust removed by cleaning system, tons	101.4	54.30	50.00
Removed by dust catcher, per cent	63.0	61.40	64.00
Removed by washers, per cent	37.0	38.60	36.00
Dust per ton of iron by dust catcher, pounds	240	156	150
Dust per ton of iron by washers, pounds	138	98.3	84.3
Total dust per ton of iron, pounds	378	255	246
Apparent recovery from washer discharge water, tons	34.4	20.95	18
Apparent loss from washer discharge water, tons	2.6	None	2.56

The matter of handling the collected dust in both methods is rather difficult; the sludge in the wet method is difficult to handle on account of leaking cars and unloading or stocking, and the winter weather also adds its difficulty. It can be pumped to storage. The Dorr thickener is an assistance in handling the sludge as it reduces the space which would be used as settling basins, and by the use of pump or syphon the sludge can be conveyed to storage or place for mixing with other ore or dry dust. Even with the Dorr thickener or settling basins there is a small loss of suspended ore dust carried away with the water. The ore which is lost beyond the Dorr thickener or settling basin can be saved by the use of the Oliver filter.

The dust from the dry cleaner furnishes difficulties, such as preventing the wind from blowing it away when removing from cleaner into cars, and in its disposal. The loss is less than that carried away by the wet method.

Progress in gas cleaning has been slow for various reasons and the amount of flue dust lost and for which there is no account is large. The difference between the theoretical and actual yield and flue dust produced should

be accounted for within a reasonable limit, and with good cleaners, wet or dry, it can be done. Based on a production of 20,000,000 tons of pig iron, using 3,955 lbs. of ore, 336 lbs. of scale and cinder, and 51 lbs. of scrap (difference between 109 lbs. used and 58 lbs. produced) per ton of iron, the theoretical yield should be 55%. If the actual yield is 51%, the loss then follows as 4%. The theoretical yield of 55% gives 2,360 lbs. of iron from ore, scale and cinder, but the actual production would be 2,188 lbs., the balance of the ton being made up of scrap used. The difference between 2,360 and 2,188 lbs. is 172 lbs. of iron. We account for 267 lbs. of dust, natural or wet. One hundred and seventy-two lbs. of iron would be equivalent to 400 lbs. of dust of 43% iron content for each ton of iron produced. Using standard practice for dust produced and accounted for and based on 20,000,000 tons of pig iron, there should be resultant 2,383,900 tons of dust, whereas the loss of 4% expressed in 43% dust is 3,571,400 tons. This shows an amount unaccounted for of 1,187,500 tons. I know of one group of blast furnaces in the United States Steel Corporation that for the past twelve years, by cleaning its gas and saving and using the dust recovered from the gas system, has averaged less than 1% difference between the theoretical and actual yield.

The art of producing pig iron is not so far developed as to save every ton of iron in the raw material, but with good dust catchers and gas washers or gas cleaners of some economical type, we could possibly save 775,000 tons of the above mentioned 1,187,500 tons, which would be available to briquette, sinter, use raw, or mixed with the ore in the ore yard. This is used as an illustration of what should be done to save that which is lost in the gas system.

For refined washing of gas for use in gas engines, the best known apparatus is the Theisen washer.

For stoves and boilers it is not necessary to have an apparatus for the highest degree of efficiency.

Engineers today are endeavoring to develop ap-

paratus which will permit the most economical use of this by-product and will produce a handsome credit to the blast furnaces. That which eighty-seven years ago was a waste has now developed to be a by-product of great value and in preparing this by-product we have recovered a lost raw material.

THE CHAIRMAN (Mr. W. A. Rogers): The second discussion of the paper "The Cleaning of Blast Furnace Gas" is by Mr. N. H. Gellert, Gellert Engineering Company, Philadelphia, Pa.

Discussion by N. H. GELLERT

Gellert Engineering Company, Philadelphia, Pa.

In the comprehensive resume of the various types of blast furnace gas cleaners which Mr. Hohl has prepared for this meeting, he has brought out several points of interest in comparing the economies of the wet versus the dry method of cleaning gas.

The blast furnace industry has for years been expecting and working for a cleaning device that would perform all the functions of the ordinary primary wet cleaner and would still conserve the sensible heat which is inherently contained in the gas. The various types of dry cleaners which Mr. Hohl mentions have been the result of the efforts made in the last five years or more to satisfy this need in the industry.

As Mr. Hohl has pointed out, gas cleaned by a dry method retains the sensible heat, which often amounts to ten or as high as fourteen per cent. of the total furnace heat.

The saving in sensible heat is calculated to amount to 52 pounds of coal per ton of pig iron made, and may be said to be equivalent to an equal amount of coke. At $6 per ton for coke charged into the furnace, the saving amounts to 15.6 cents per ton of pig iron made.

But there are other more or less intangible advantages in the use of a dry cleaner which often cannot and

do not appear on a cost sheet. There is, for instance, the absence of the sludge nuisance. A dry cleaner removes dust and fume from the gas in a dry state. There are no tanks, no thickeners, and no filters necessary in the handling of this material and while a dry cleaner may occupy of itself more ground space than a wet cleaner, it does not occupy as much space as a wet cleaning system when the auxiliaries of a wet cleaner are included.

The moist gas from a wet cleaner, often entraining mechanical moisture, may cause the residual dust in the gas to deposit along the mains of the gas system, and bake into a hard mass in the bottom of the mains and often in the stove burners themselves. On the other hand, the residual dust in a dry cleaned gas lies in the form of a loose material in the bottom of the mains, and is not only more easily removed from the mains but is often picked up by the scouring action of the flowing gas.

Comprehensive dry cleaning plants also require less labor than wet cleaning plants with all their accessories. One man will handle a dry cleaning plant for one, or two, or more furnaces if the plants are centralized. All the auxiliaries for the dry cleaning plant are in a sub-station where the attendant is placed; and therefore the labor charge is less to accomplish the same purpose than with a wet cleaning plant.

Then too, in communities where scarcity of water is a problem, dry cleaning plants afford a relief that is not afforded by any other system.

The method of cleaning gas electrically by the Cottrell process is not new and was successfully applied to other industries long before its successful development in the blast furnace industry.

The first Cottrell plant built for cleaning blast furnace gas, which was installed at Dunbar in 1919, was a pioneer plant in many respects, as it was the first large scale attempt to clean all the gas coming from a blast furnace. That a great deal of grief was experienced is only natural and that a great many changes had to be

made is of course conceded. But the plant was put into successful operation and relieved a situation at Dunbar which had become intolerable, for the ores used were very fine, and, especially in the manufacture of ferromanganese, the fume content was very great. Wet washers had been tried and had failed to give relief at this particular plant.

The second installation was made at Sheridan, Pennsylvania. In so far as it has had the capacity, it has given satisfaction. However, from the experience of the years of operation of these two plants, was developed the standard type precipitator which may now be fabricated in the shop and set up in the field almost as a unit. One of these standard units was installed last year by the Colorado Fuel and Iron Company at their Minnequa Works, in Pueblo, Colorado, to demonstrate for themselves the feasibility of the process on their own local conditions. The results of the test over months of time were so satisfactory to them that they are installing a Cottrell cleaning plant large enough to handle all the gas which issues from two of their blast furnaces. The design for this plant is now in process of completion and it is hoped that the large plant will be running in seasonable time. By means of the standard unit, it is possible to add additional equipment to an existing plant in order to take care of additional furnaces.

The whole electrical cleaning plant is extremely simple, involving a small electrical house and approximately eight of the standard units for a five hundred ton furnace. As these units are nothing more than cylindrical steel shells filled with vertical six inch pipes through the center of each of which is suspended a wire, there is nothing in the precipitator proper to get out of order. No resistance is offered to the flow of gas other than that of the few turns which the gas must take to get down to the bottom of the pipe and up to the top of the precipitator, and out. The actual cross sectional area of the pipes is greater than the cross sectional area of the supply main.

The cleaning effect is obtained by passing the gas through an electrical field which is present in each of the pipes in the form of a corona discharge, which may be seen by the eye to be a purple glow around each wire. As the gas passes through this electrical field, it is ionized and each particle of dust receives a charge of electricity which causes it to be impelled to the sides of the grounded pipes. These particles of dust will stay on the side of the pipe until the current is taken off and hammers, which are suitably placed in the precipitator, by tapping dislodge the particles of dust and cause them to drop into a bottom hopper. The current which is furnished for this purpose is obtained by stepping up ordinary 220 volts or 440 volts, 25 or 60 cycle current to a voltage of 35,000 to 40,000 volts by means of a specially designed transformer and then converting this high tension alternating current to a uni-directional or direct current by means of a mechanical rectifier.

This would seem complicated but the entire electrical equipment for two standard units, as already described, consists of a switchboard, transformer, mechanical rectifier driven by a 2 horsepower motor and the insulators which are necessary to sustain the high tension equipment. All of these pieces of electrical equipment have been used for years and are built by the most prominent electrical manufacturing companies in the country. While they are special for precipitation, they are more or less standard and not laboratory devices.

By using a lower voltage, instead of a voltage running up to 75,000 or 100,000 volts, the greatest difficulty that was encountered in the beginning has been eliminated, for insulators can be designed to withstand 35,000 or 40,000 volts in precipitation duties, when they might give difficulty with 75,000 or 100,000 volts.

While the original plants were built with their large insulators on the inside of the shell, the new plants are built with the insulators on the outside of the shell.

The results obtained by cleaning gas with electrical precipitation have shown the process to be thoroughly commercial and thoroughly satisfactory. Efficiencies as high as ninety-seven per cent. have been secured and gas has been cleaned so that the outlet gas contained a little over one-tenth of a grain of dust at standard conditions. Some of the tests, made when the furnace was slipping badly and the inlet gas contained ten grains of dust per cubic foot, showed that the outlet gas contained about one-half a grain of dust per cubic foot.

In one of the tests made, the stove efficiency was increased one-third. Savings of gas in the stove as high as thirty to thirty-five per cent. were shown when using gas cleaned by this process as against dirty gas.

To clean all the gas from a five hundred ton furnace would require only about 60 K. W. This includes the current necessary to electrify the wires in the pipes, to run the small motors which operate the synchronous motors, and to operate the automatic devices which intermittently clean the dust from the precipitator units. The whole equipment, as it is being designed for Colorado, will be automatic. It will be self rapping, contacts will automatically shut and open dampers, operate the rappers, cut off the current and put it on again.

Due to the savings obtained by the use of the Cottrell system, it is calculated that an installation will pay for itself in about two years, if it is installed in a plant where dirty gas is being used, and in about four years, if substituted for wet cleaning plants.

THE CHAIRMAN (Mr. W. A. Rogers): The next paper is Power Consumed in Rolling Steel, by Mr. Gordon Fox, Electrical Engineer, Freyn, Brassert & Company, Chicago, Ill.

POWER CONSUMED IN ROLLING STEEL

Gordon Fox

Electrical Engineer, Freyn, Brassert & Company, Chicago, Ill.

Although power is not ordinarily a major factor in conversion costs, nevertheless it is of sufficient magnitude to warrant careful consideration.

The use of electric drive greatly facilitates the securing of power consumption data. In spite of this fact there has been published comparatively little specific information on this subject. Many mills secure only such data as is necessary for monthly cost distribution purposes. In some instances the electrical distribution and metering systems are such that extended "estimating" is necessary to obtain even these data, and power cost figures are correspondingly debatable. The possibilities for economies in power usage are not likely to be realized in the absence of complete and accurate information as to the results obtained. It is the experience of the writer that the cost of providing suitable metering equipment and obtaining sufficient records can be fully justified provided these records are analyzed and the data usefully applied. It is possible to accomplish many economies which fully justify the cost of their development. I would make this plea. If your electrical department is alive to its possibilities, do not curtail its personnel nor its facilities to a point which will not permit some investigation and betterment engineering.

Ratio of Demand to Connected Load

It is of interest to note a material uniformity among plants in the matter of power consumed as related to

horsepower of motors connected. Naturally, there is some variation between plants differing in size and character. Table A has been prepared presenting data as to the normal average power consumption of several plants of varied size and type.

TABLE A—RATIO OF CONSUMPTION TO CONNECTED LOAD, BY PLANTS

Character of Plant	Connected HP of Motors	Total Average Monthly Electric Consumption KW Hours	Ratio Average KW to Connected HP, Per Cent
Merchant blast furnace:			
Exclusive of pumps	2,672	242,000	13.9
Inclusive of pumps	3,522	692,300	30.2
Coke ovens, blast furnaces, open-hearth and mills. Mills steam driven	13,584	1,550,000	17.6
Coke ovens, blast furnaces, open-hearths and mills. Mills part steam and part electric drive	71,314	8,960,000	19.3
Coke ovens, blast furnace, open-hearth and mills. Electric drive throughout	34,250	4,750,000	21.3
Open-hearth and mills. Mills part steam, part electric drive	13,740	1,456,000	16.3
Open-hearth and blooming mill. Electrically driven mill	7,203	1,110,000	22.4
Open-hearth, blooming mill and finishing mills, all electrically driven	34,924	5,506,800	24.3
Finishing mill producing hoop, hot and cold rolled, from billets. Electric drive throughout	5,403	1,098,000	31.5
Wrought iron mill. Busheling and piling. Steam driven squeezer and mills. Electrically driven auxiliaries. Lighting relatively large item	721	107,500	37.0

The relation of power consumption to connected horsepower varies materially between departments in a given plant. Table B shows the relative power consumption of motors by departments in one plant. At the blast furnace, open-hearth and soaking pits, the drives are largely of the intermittently operated type and the use factor is relatively low. In the rolling mills, the influence of the main drives leads to a higher use factor. At the pipe mills, much of the machinery is of the steady run-

ning type and friction load is a ruling element, hence a relatively high use factor.

TABLE B—RATIO OF CONSUMPTION TO CONNECTED LOAD BY DEPARTMENTS

	Ratio Average KW to Connected HP, Per Cent
Blast Furnace (exclusive of pumps)	10.3
Open-Hearth	13.5
Soaking Pits	10.5
Blooming Mill	28.5
Billet Mill	21.2
Plate Mill	26.2
Skelp Mill	24.9
Pipe Mill	33.5

Power Consumed by Main Roll Drives

In rolling blooms, billets, slabs, sheet bars, plates, strips and similar shapes the metal is displaced largely in the direction of rolling. It has been found that the power required for this class of rolling is a reasonably consistent result of several governing factors. In rolling special shapes in closed passes, such items as side displacement, indirect pressure, collar friction and end thrust complicate the problem to such an extent that no formulae are applicable and determinations of power must be based on precedent.

In simple rolling, the power requirement is a function of the volume of metal displaced. It may also be considered with reference to elongation, which is a related factor.

If all conditions remained the same throughout a simple rolling operation, the power required per cubic inch of metal displaced would be a fixed quantity. Several changing conditions serve to modify this relation. Foremost among these is temperature. Cold rolling requires roughly twenty times the power of hot rolling per unit displacement. A drop of 400° F. in temperature approximately doubles the power required. This relationship is shown in Fig. 1 which has been prepared from

data presented by Mr. G. P. McNiff (Chemical and Metallurgical Engineer, 1920, p. 660).

The degree of temperature variation throughout a rolling operation depends upon the size and shape of the section, with particular reference to the area exposed

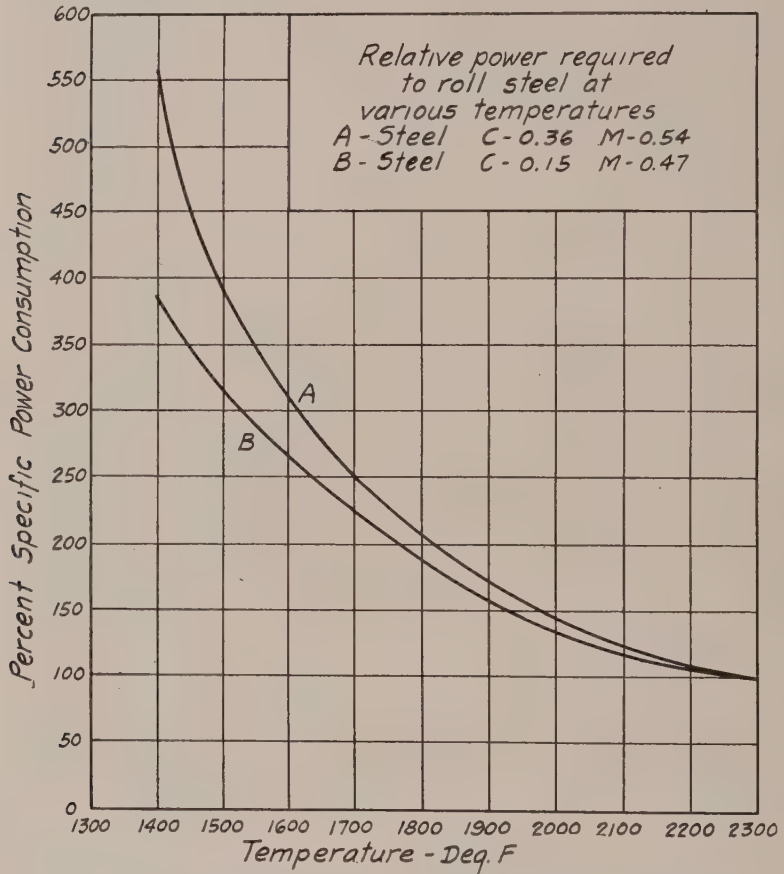


Fig. 1—Relative power required to roll steel at various temperatures.

per unit of volume. The time of exposure has a direct bearing. This is affected by the number of passes, the type of mill, the speed and the method of handling and reducing the steel. The curves shown in Fig. 2 from data by Mr. G. E. Stoltz (Proceedings, A.I.S.E.E., Dec., 1922) are of interest as examples, showing the range of temper-

ature variation in two mills of the semi-continuous and continuous types rolling ¼" rounds.

In the derivation of load charts for determination of power required for each pass and for combinations of passes in a proposed rolling schedule, curves showing variation in specific power consumption are of value. These curves show the variation in power demand per unit of volume displaced as the rolling proceeds. As the

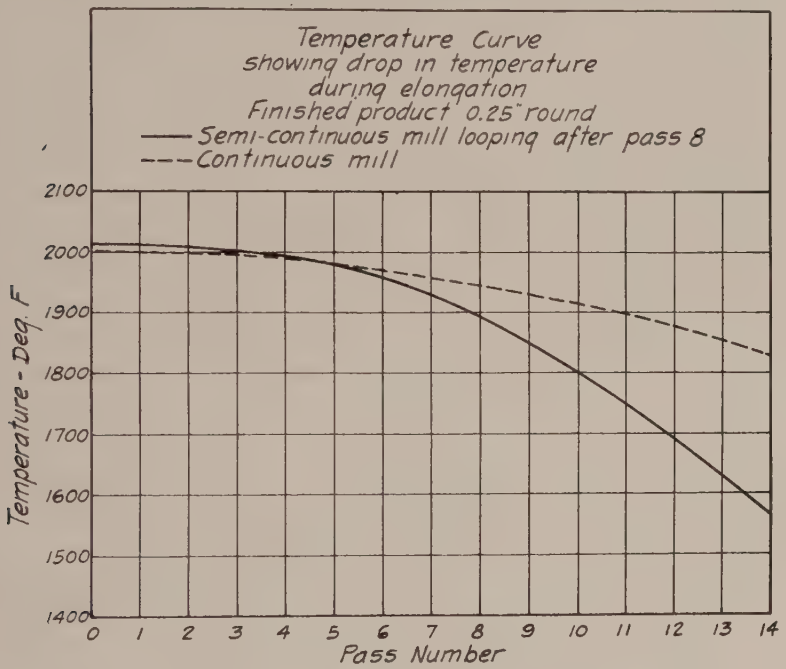


Fig. 2—Drop in temperature during rolling.

temperature of the steel is the most prominent determining factor, curves of specific power consumption are substantially the result of a combination of such curves as are given in Figs. 1 and 2, showing respectively the variation of demand with temperature and the variation of temperature with elongation or reduction in area. Fig. 3 is a derivation of this character, while Fig. 4 gives a curve of specific power consumption plotted from test data of power consumed per pass as related to metal dis-

placed. This curve is from data courteously supplied by one of the electrical manufacturers. Figs. 3 and 4 are not directly comparable as they refer to different types of mills and weight of product and the scale of ordinates differs, but a close similarity may be observed.

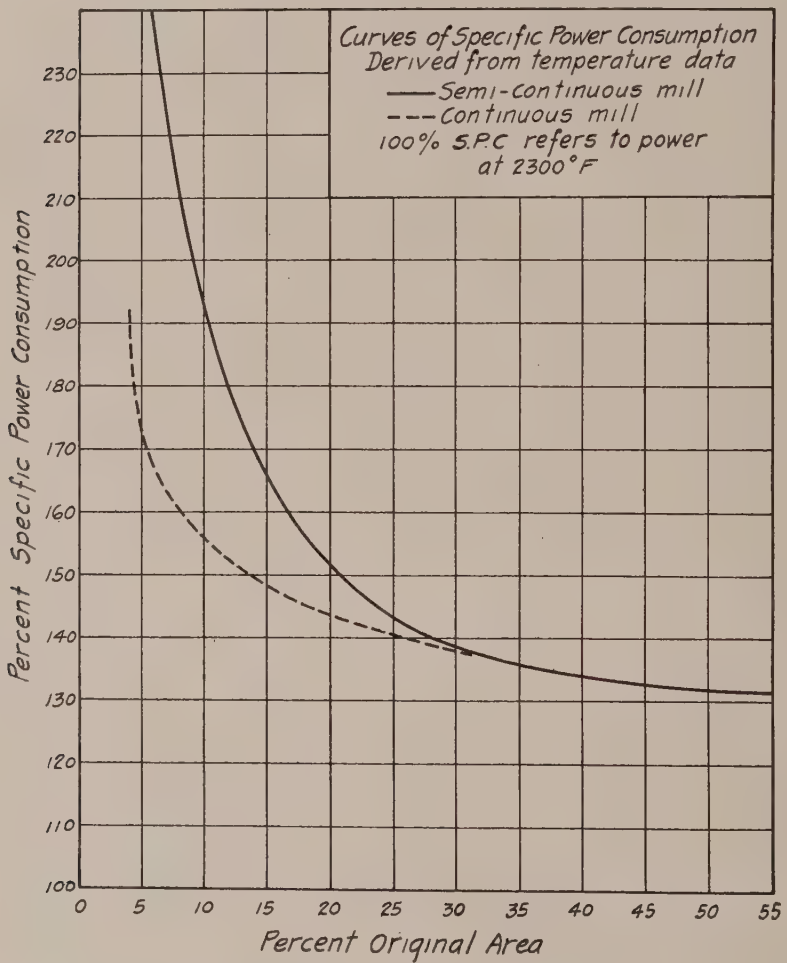


Fig. 3—Derived curve of specific power consumption.

Power Consumption versus Elongation

A very convenient measure of power consumption of various mills is the KW hours per ton. Such figures do

not mean very much, however, unless qualified by the elongation. This measure is useful for comparing or estimating the power consumption of mills producing a

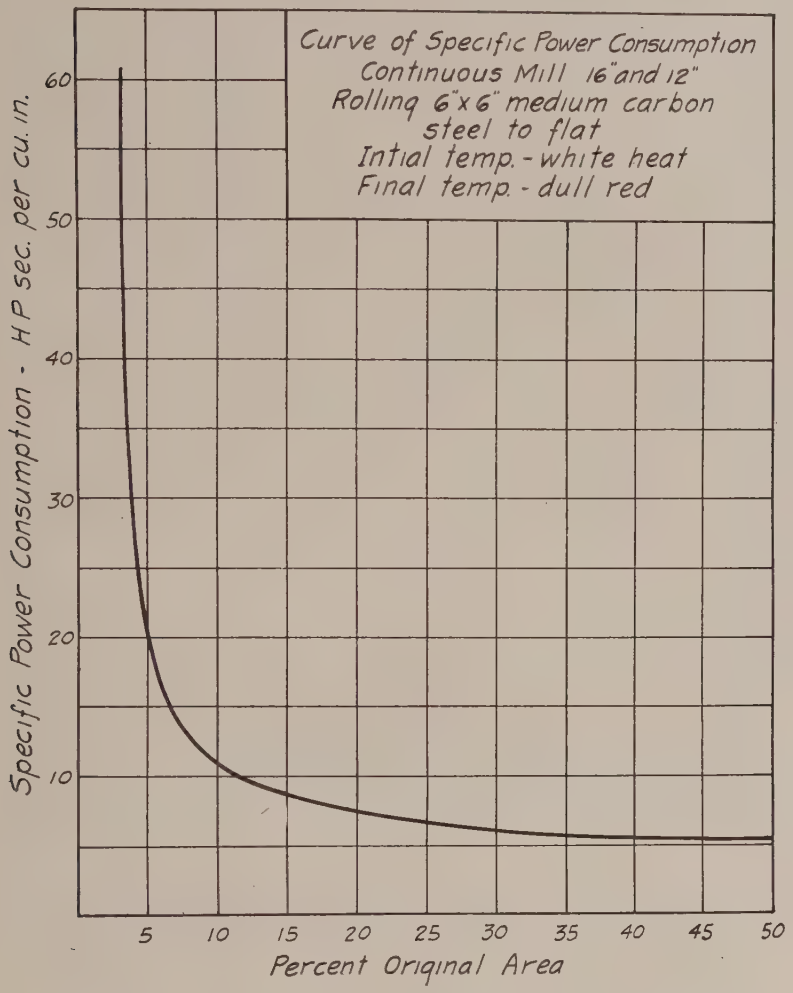


Fig. 4—Curve of specific power consumption, Continuous Mill.

given tonnage from and to stated dimensions. It is also useful as a check on the continuous capacity of motors installed.

There are presented herewith a number of curves

showing the total power consumption as related to elongation in several types of mills. These curves have been prepared from data obtained through the courtesy and co-operation of the management and the electrical departments of several mills.

Due to many variable factors, but mainly due to variation of tonnage per unit of time, the points which establish these curves are more or less scattered, but lines

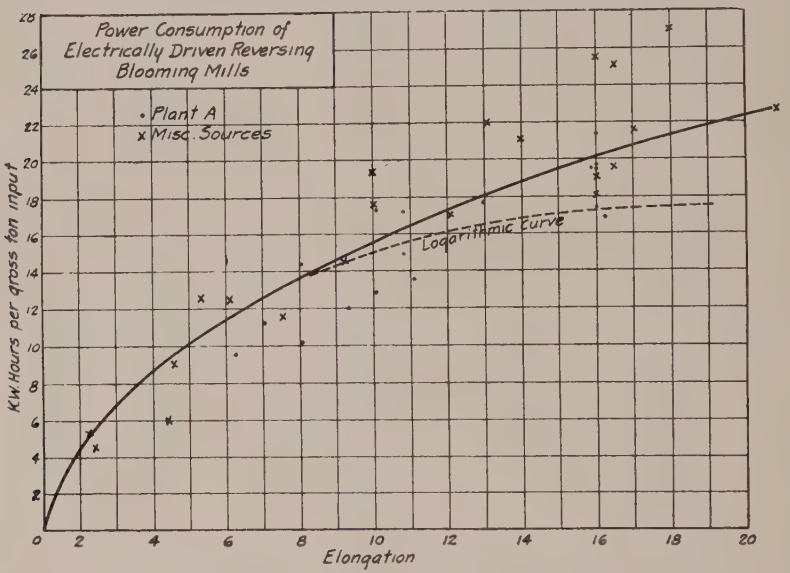


Fig. 5—Power consumption of Reversing Blooming Mills. Plant A: 40″ reversing blooming mill. Motor, 1,980,000 lb. ft. maximum torque, 0–120 R.P.M. Normal output, 74 tons per hour. Record turn output, 124 tons per hour. Friction load of flywheel set only, 175 K.W. Average power consumption, 18.5 K.W. hours per gross ton finished.

may be drawn through them which are representative of average conditions. The points are shown so that the extent of variation and departure from the average condition may be noted.

Theoretically and if the specific power consumption remained constant, it should require the same amount of power to elongate from 1 to 2 times, 2 to 4 times and 4 to 8 times, etc., the original length, since the volume displaced in each case is the same. The theory above out-

lined gives a logarithmic curve in which power consumed is proportional to the logarithm of the elongation.

For the sake of interesting comparisons, there has been plotted on each curve sheet a theoretical logarithmic curve to which the actual derived curve is tangent and which blends with the derived curve for small elongations. This logarithmic curve indicates about what might

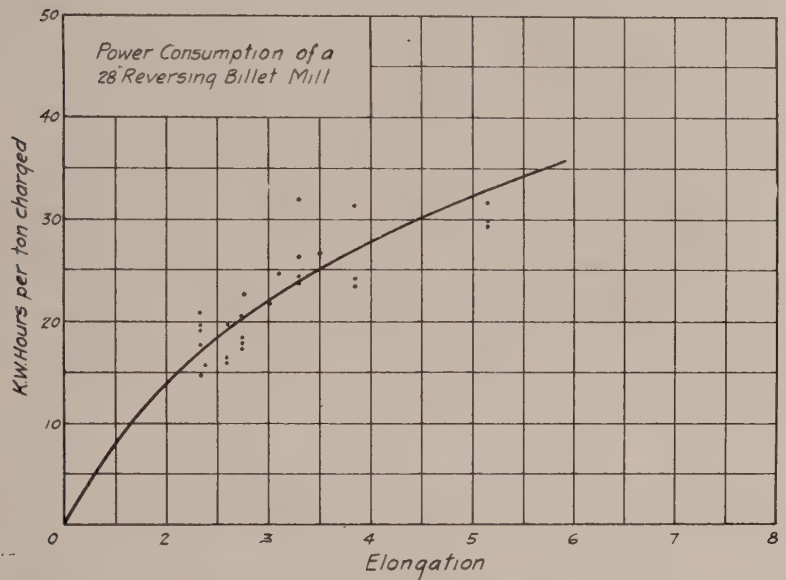


Fig. 6—Power consumption of a 28″ Reversing Billet Mill. Motor, 375,000 lb. ft. maximum torque, 0–40–125 R.P.M. Normal output, 25 tons per hour. Record turn output, 32 tons per hour. Friction load of flywheel set, blower and exciter, 140 K.W. Average monthly consumption, 21 K.W. hours per ton.

be expected if the specific power consumption were constant, if the temperature during rolling did not vary and if the friction load were proportional to the displacement. The departure of the actual curve from the logarithmic curve is of interest as indicating primarily the effect of cooling and the resultant increase in specific power consumption. It will be noted that, in the case of the blooming mill, the actual and theoretical curves do not differ greatly, due primarily to the fact that the steel

does not cool rapidly in this type of mill. In the sheared plate mill the consumption appears to be somewhat higher than in the universal plate mill for a given tonnage and elongation. The departure from the logarithmic curve in the two cases is similar, indicating the same general extent of cooling. A mill of the semi-continuous

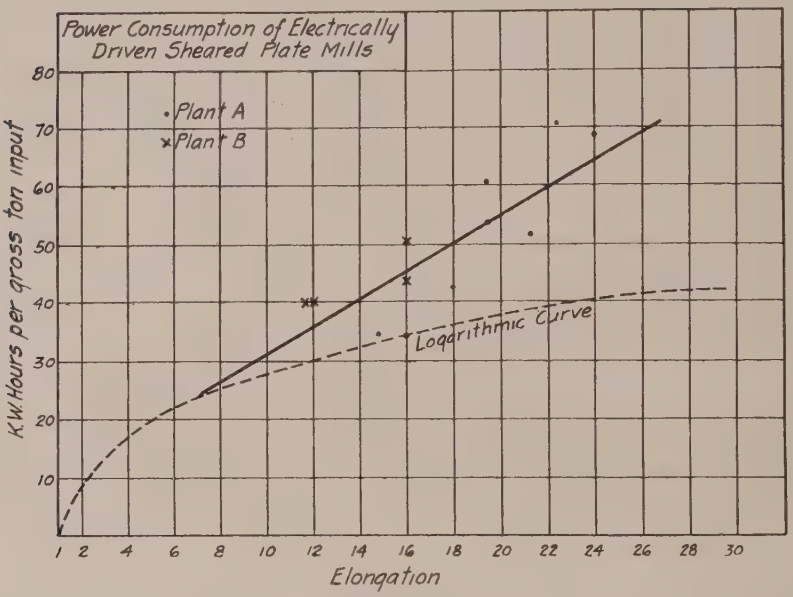


Fig. 7—Power consumption of Sheared Plate Mills. Plant A: 84″ Tandem Plate Mill with 32″ reversing roughing stand and 32″ and 22″ Lauth finishing stand. Roughing motor, 1,000,000 lb. ft. torque, 0–40 R.P.M. Finishing motor, 2,500 H.P., 240 R.P.M. Gear drive with flywheel. Mill speed, 53 R.P.M. Normal output, 16.7 long tons per hour. Record turn output, 33.3 long tons per hour. Friction loads; roughing mill and motor, 220 K.W.; flywheel set, blower and exciter, 145 K.W.; finishing mill and motor, 205 K.W. Plant B: 100″ Lauth Plate Mill with 32″ and 22″ rolls, driven by a 2,000 H.P., 245 R.P.M. motor by rope drive. Pinion speed, 77 R.P.M. Mill speed, 50 R.P.M. Normal output, 17 tons per hour. Record turn output, 61 tons per hour. Friction load of mill and drive, 190 K.W.

type, such as shown in Fig. 10, and one rolling very light product, such as shown in Fig. 11, show wide departure from the logarithmic curve resulting primarily from rapid cooling. A mill of the continuous type, as shown in Fig. 9, does not show so wide a departure as the temperature is better maintained.

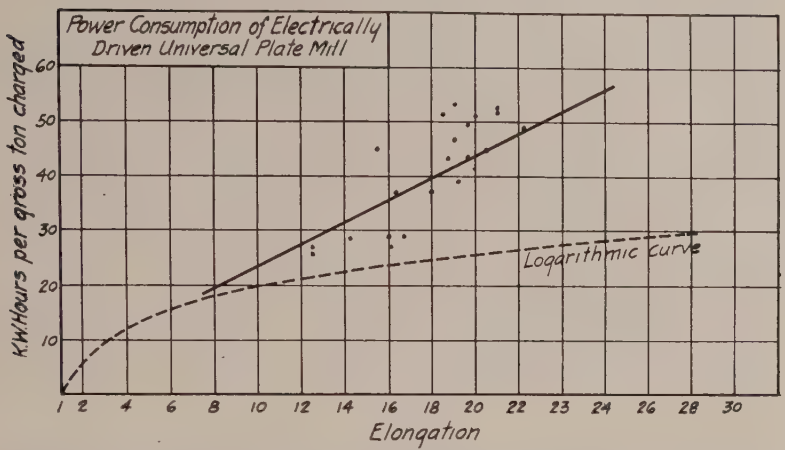


Fig. 8—Power consumption of a Universal Plate Mill. Rolls, 30″ diameter; maximum width of universal plate, 48″. Motor, 8,000 H.P., 880,000 lb. ft. maximum torque, 0–47–125 R.P.M. Roll speed at 47 R.P.M., 370 feet per minute. Normal output, 22 tons per hour. Record turn output, 45 tons per hour. Friction load of flywheel set, blower and exciter, 165 K.W. Average power consumption of main drive, 34 K.W. hours per ton.

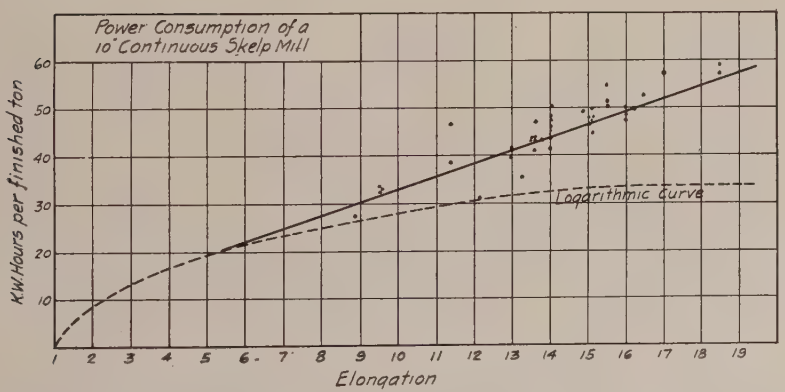


Fig. 9—Power consumption of a Continuous Skelp Mill. Roughing mill comprises five horizontal and two vertical stands; edging rolls, 1 vertical stand; finishing mill, three horizontal stands. All stands, 10″. Roughing stand gear driven by a 2,000 H.P. Kramer set, 234 to 360 R.P.M. Finishing stand belt driven by a 2,000 H.P. Kramer set, 161 to 230 R.P.M. Friction load, roughing mill and drive, 100 K.W.; finishing mill and drive,150 K.W. Normal output of mill, 22.5 tons per hour. Record turn output of mill, 42.5 tons per hour. Average power consumption of main drives, 52 K.W. hours per ton.

To render the curves of greater comparative value, some pertinent data is given concerning the mills to which the curves apply.

Power Consumption versus Rate of Rolling

In general it may be said that, of the total power consumed in rolling steel, from 10 per cent to 30 per cent is

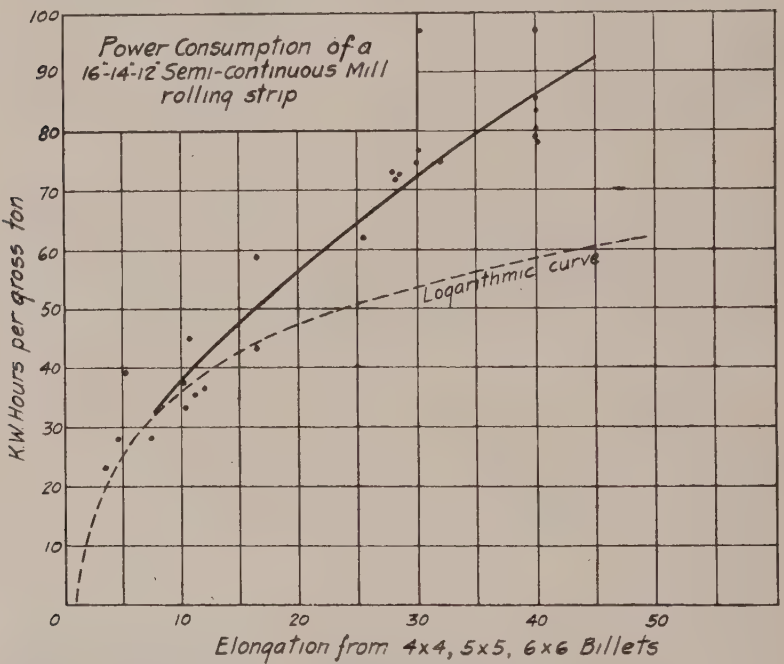


Fig. 10—Power consumption of a Semi-Continuous Strip Mill. Mill comprises six stands, 16″ roughing semi-continuous; six stands finishing mill, staggered duo, 4 stands 14″ and 2 stands 12″. Roughing motor, 1,200 H.P., 78 R.P.M., driving through gears. Finishing drive, 2,000 H.P., 250 to 150 R.P.M. Kramer set with belt drive. No flywheels. Normal output, approximately 20 tons per hour. Friction load of roughing mill and drive, 175 K.W.; finishing mill and drive, 200 K.W.

represented by friction load, that is, the equivalent of idling loss over the full period of time considered. The relative value of the friction load is a function of the tonnage per unit of time. Delays, an excess number of passes, and slow handling of the steel between passes, contribute to a relatively high frictional consumption.

The power required for rolling steel may be considered as comprised of two main components. The idling friction component is taken as a constant quantity and is proportional to time. The rolling power component involves both the displacement of the metal and all other contributory items. This load is closely proportional

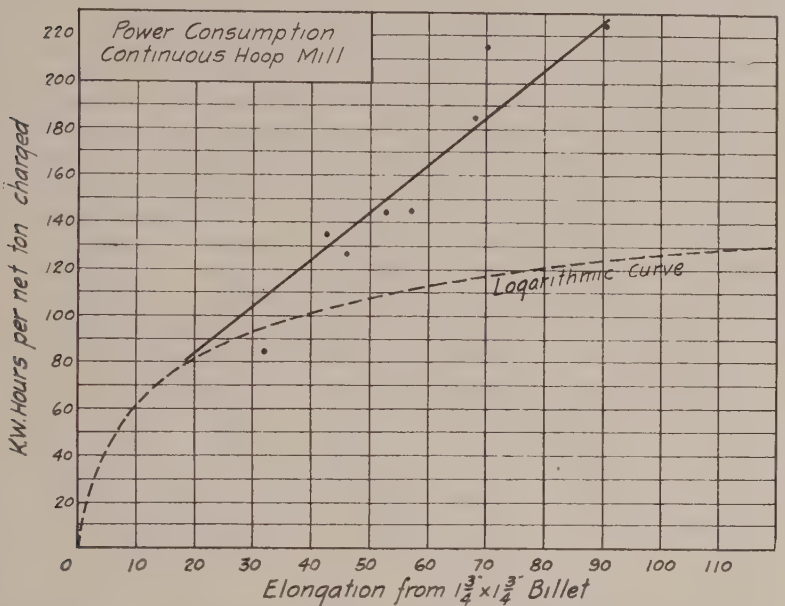


Fig. 11—Power consumption of a Continuous Hoop Mill. Roughing mill consists of six 10″ stands, gear driven by a 900 H.P., 197 to 325 R.P.M., Scherbius set. The edging rolls are driven by a 100 H.P. motor. The finishing mill consists of five 10″ stands, belt driven by a 1,800 H.P., 160 to 240 R.P.M., Scherbius set. Normal output, about 10.5 tons per hour. Record turn output, 21 tons per hour. Friction load of roughing mill and drive, 75 K.W.; finishing mill and drive, 300 K.W. Average power consumption, 165 K.W. hours per ton.

to the tonnage produced (for a given rolling order). The total power consumption is the combination of these two components. In Fig. 12 is shown how the total power consumption over 24 hours varies according to the tonnage output over this period (Curve A). From the total consumption and the corresponding tonnage a series of values of KW hours per ton may be derived (Curve B).

It should be clearly apparent, from this curve how decidedly the power consumption is influenced by the rate of rolling. This may be further enhanced by a higher unit cost of electric power for lesser quantity. From the point of view of power consumption it is highly desirable to keep a mill full.

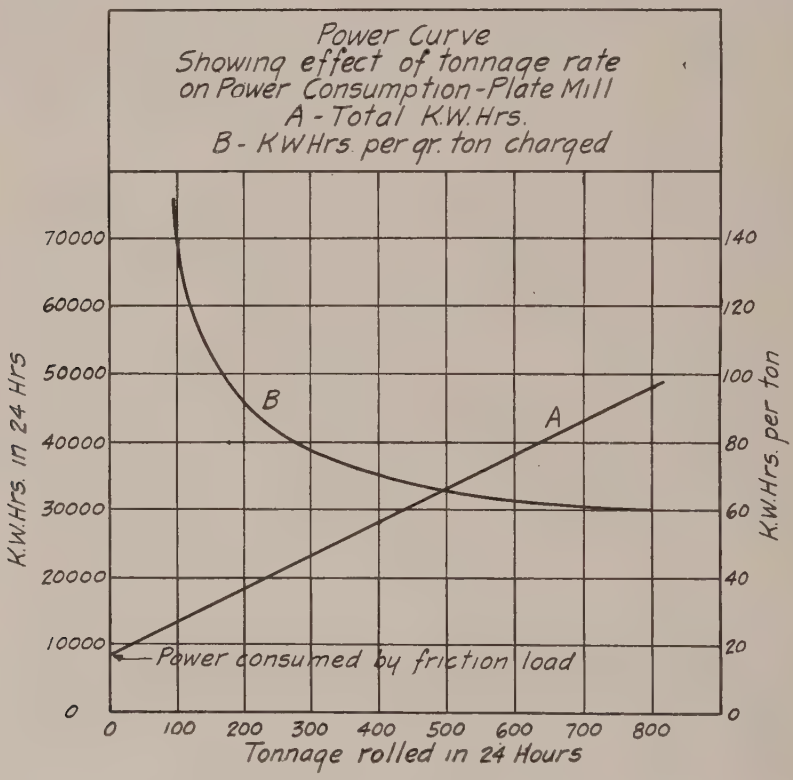


Fig. 12—Theoretical influence of tonnage rate on power consumption.

To show how closely the principle above outlined is substantiated in actual practice, Fig. 13 has been prepared. This curve, which is similar to Curve B, Fig. 12, has been derived theoretically from the known friction load of the mill and the average power consumption of a

given rolling order. A number of points are shown giving actual consumption data over a range of output from 167 to 370 tons per turn, all on the same rolling order. The actual points seem to check the derived curve very well.

To show further the influence of rate of output on power consumption per ton, there is shown in Fig. 14

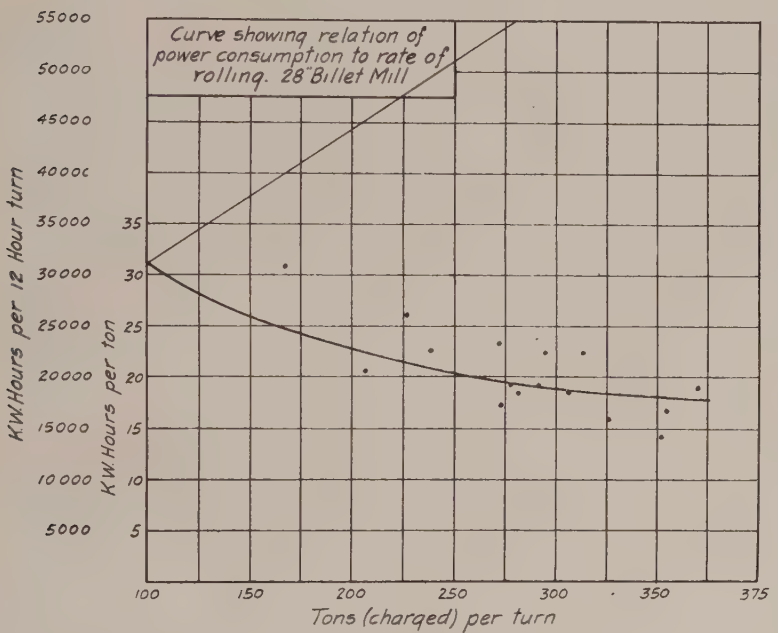


Fig. 13—Relation of power consumption to output of a Billet Mill.

the tonnage output of a universal plate mill by months over a year together with corresponding data as to KW hours per ton. This is representative of an average of rolling orders. As the average elongation will vary some from month to month, complete consistency cannot be expected, but the general theorem is quite clearly demonstrated.

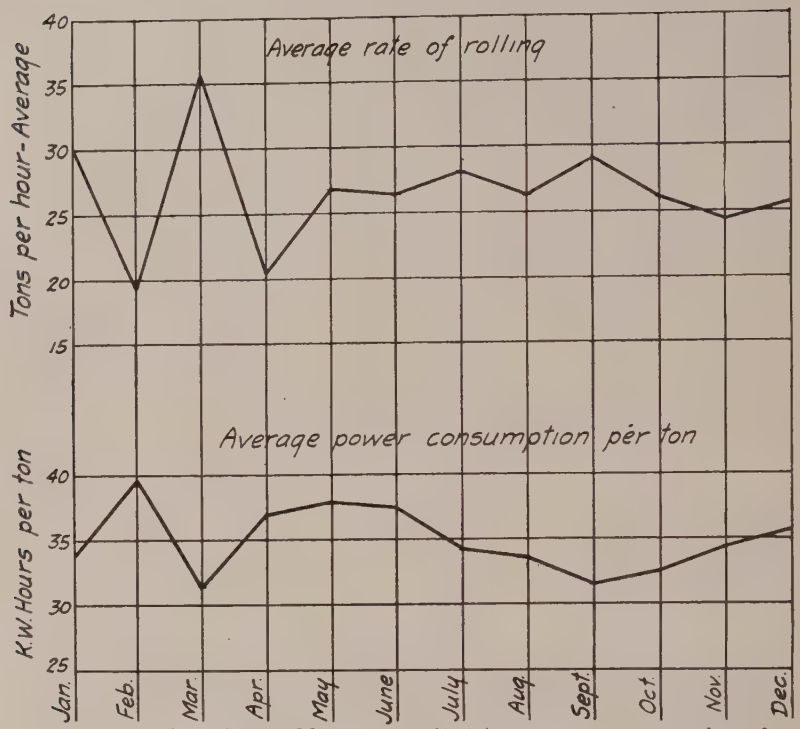


Fig. 14—Relation of monthly tonnage (1919) to power consumption of a Universal Plate Mill.

THE CHAIRMAN (Mr. W. A. Rogers): Discussion by two gentlemen, first by Mr. J. D. Wright, General Electric Company, Schenectady, New York.

Discussion by J. D. WRIGHT

General Electric Company, Schenectady, N. Y.

The paper presented by Mr. Fox is a valuable contribution to the data which have been published on the subject of power consumed in rolling steel.

I shall confine my discussion to a few remarks, illustrated by diagrams, concerning the relation between power consumption and rate of rolling.

It is unquestionably a fact that the rate of rolling has a decided influence on the power consumption for a given rolling order, provided the mill is allowed to run during the time of delays. However, if the motor drive is shut

down when waiting for steel, the idling friction component is absent and the power consumption will not vary appreciably with different tonnage rates.

To illustrate this, Fig. 1 has been prepared. It shows the tonnage rolled per month on a Morgan continuous mill together with corresponding data on kilowatt hours per ton. The elongation is a practically constant quantity. There is no evidence of an increase in power consumption with decrease in production.

Fig. 2 shows the relation of power consumption to rate of rolling on a motor-driven rod mill. The left-hand curve shows kilowatt hours per ton plotted against tons per hour. The points on this curve were plotted from data obtained each hour for twenty-four consecutive hours when the mill was rolling No. 5 rods from 1¾″ square billets. The motors were allowed to run continuously and the resulting "rising characteristic" of the power consumption curve with decrease in tonnage is clearly evident.

The right-hand curve shows kilowatt hours per ton for monthly productions and illustrates the fact that with average monthly figures the rising characteristic is lacking.

This is also illustrated by Fig. 3, which shows the relation of power consumption to rate of rolling on a motor-driven sheared plate mill. The rolling conditions differ from those from which the rod mill data were plotted in that a number of different sizes of plates are produced. The elongation will vary over a wide range for different orders. However, the power consumption does not show any decided tendency to be higher when the production is lower.

Fig. 4 shows the kilowatt hours per ton on a monthly basis for a 40″ reversing blooming mill. The power consumption varies from month to month due to variations in average elongation, but it will be noted that the tonnage rolled is not an important factor in affecting the power consumption. The lowest monthly produc-

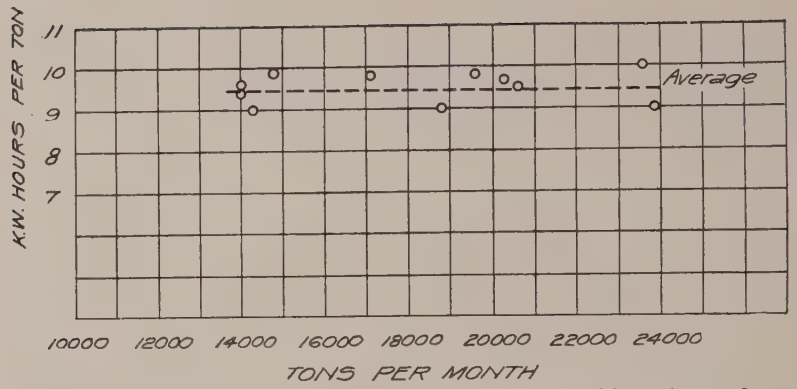


Fig. 1—Relation of power consumption to rate of rolling, six-stand continuous bar mill.

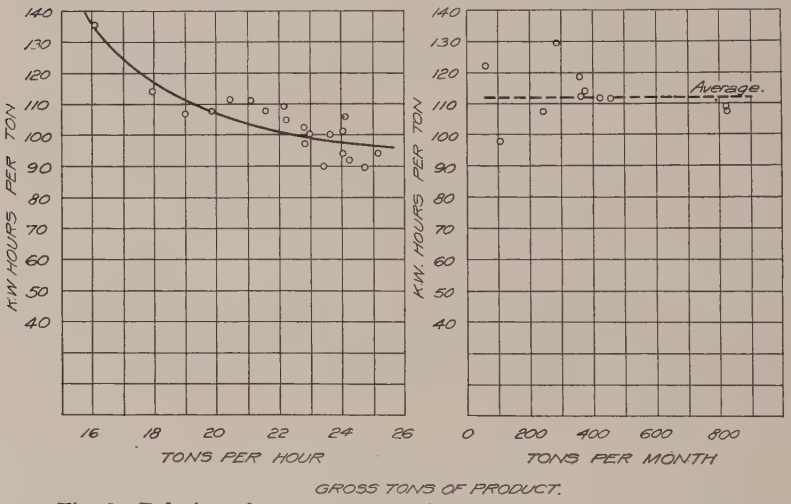


Fig. 2—Relation of power consumption to rate of rolling, rod mill.

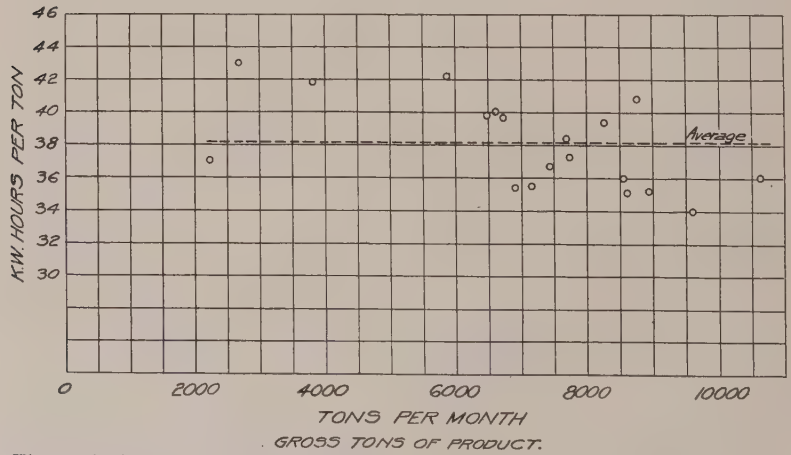


Fig. 3—Relation of power consumption to rate of rolling, sheared plate mill.

tion, 22,250 tons, had a power consumption of 17.5 K. W. H. per ton whereas the maximum monthly tonnage, 58,000 tons, was produced at 17.1 K. W. H. per ton.

In view of these data, I feel that this statement may safely be made: With a motor-driven mill having the usual variety of rolling orders it may be expected that the average power consumption when rolling at a low monthly rate will not differ to any appreciable extent from the average power consumption when rolling at a high monthly rate.

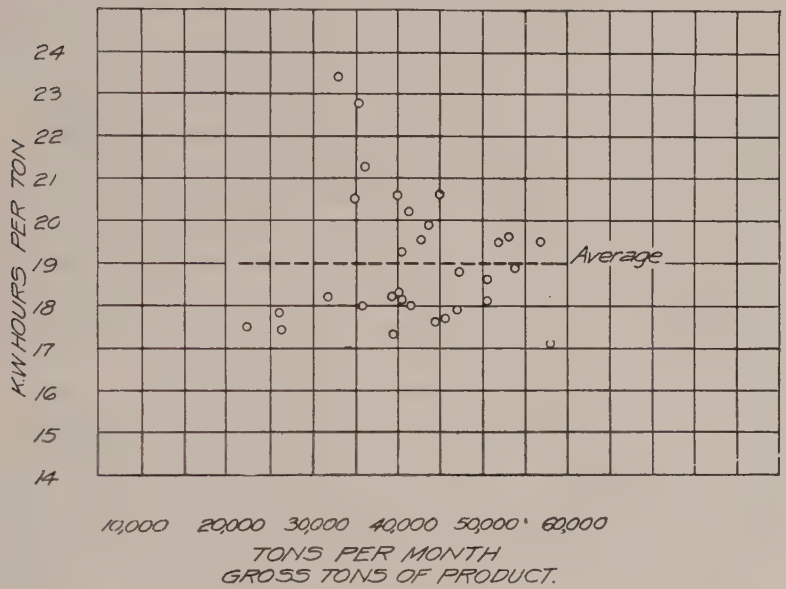


Fig. 4—Relation of power consumption to rate of rolling, 40″ reversing blooming mill.

The Chairman (Mr. W. A. Rogers): The second discussion of the paper on Power Consumed in Rolling Steel is by Mr. E. Friedlaender, Edgar Thomson Works, Carnegie Steel Company, Braddock, Pa.

Discussion by E. Friedlaender

Superintendent, Electrical Department, Carnegie Steel Company, Braddock, Pa.

I believe that the gentlemen present are mainly interested in final results of engineering and do not care to

go into technical details. I shall therefore not confine my discussion strictly to the topics brought out by Mr. Fox, but make a few remarks on the economic use of power in the steel plant.

As stated, the cost of power is a comparatively small item in the cost of production of steel, and in the past little consideration was given the economical use of fuel for power generation. The greatly increased cost of fuel and labor together with enormously grown application of electric motors has brought the cost of power in the steel plant to a height that can no longer be overlooked.

The steel industry is the second largest consumer of coal in the United States and must do all possible to use it economically. There is no other industry as highly developed. Our government tells us that over 25% of all coal mined in this country is wasted, and requests us to conserve this fuel as much as possible, as the future industrial welfare of our country will depend greatly on our fuel reserves. Over one hundred million tons of coal are used in the steel industry each year, about twice the theoretical requirement. The coal wasted would be sufficient for the domestic use of the entire country.

In order to study intelligently the problem relating to the economic use of fuels for metallurgical or power purposes, a "plant heat balance" should be prepared. The future ideal steel plant will probably burn very little if any coal under boilers. By-product coke oven plants will coke all coal for blast furnaces and furnish gas for heating steel, driving gas engines, and generating steam for large turbo-generators.

By improving methods of operation or design and equipment of old boiler plants, efficiencies below 50% can be brought up to 80%. Twenty-five million tons of coal were saved during the war in one year in this country without making any changes in the boiler equipment.

The small, inefficient, individual power plant has been replaced by large modern, central stations. The steel plant is the largest uneconomical consumer of coal today

in the United States. The time is not far away when an obsolete, wasteful steel plant will not be able to make any profit or compete with an up-to-date plant.

The electrification of mills driven by wasteful steam engines offers the greatest opportunity for effecting economies in the steel industry. Such developments run more in the direction of economics than engineering.

The practice of adding small generating units whenever needed to the generating system must be done away with. Such units use up to 6 lbs. of coal per K. W. H. whereas large turbo-generators are now guaranteed not to exceed 1.7 lbs. per K. W. H.

The very efficient transmission and the insignificant "stand by" losses of electric power have led to its very rapidly extended use in the steel plant. I believe that soon all power plants, whether hydraulic or steam turbine or gas engine driven, will feed into one general superpower system, and, in view of the ever shifting demands of the country, and of steel plants as well, will both buy and sell power. The advantages derived from such power systems would be of great benefit to the entire country. Heat or fuel would not be wasted while plants were shut down at week ends or running partially in slack times.

The author calls attention to the great value of data and records for future investigations and developments. Power consumption figures in rolling steel should always include the size of ingot, bloom, or billet entering the mill, and the size and type of finished product, in order that the elongation of the metal rolled may be calculated.

It is always difficult to arrive at the proper size of motors for roll drives, as mill operators can seldom give accurate information as to future operating conditions. Mill engines have in the past mostly been made large enough so that some part of the mill equipment will let go before there is danger of breaking the engine. Such practice cannot be tolerated today. Close attention must

be paid to efficiency and price of equipment, and last but not least, to close competition.

In Table B the author gives the ratio of power consumption to motor horsepower installed in a blooming mill at 28.5%. The low consumption of power is probably due to the installation of an electrically driven Illgner flywheel set.

Mr. Fox has given us in his paper very comprehensive curves on electric power requirements in rolling steel. For comparison, I wish to add some data on steam consumption, taken from the proceedings of the Association of Iron and Steel Electrical Engineers.

Right here I beg to call your attention to the fact that electrical data are mostly compiled from readings taken on accurate, direct reading meters, which are in daily use while motors are operating. Data on steam consumption are not so easy to obtain or so accurate and are often taken from short tests under most favorable conditions, and therefore do not represent actual working practice.

"A 50″x72″ simple reversing blooming mill engine used 882 lbs. of steam per ton rolled, equal to 9 lbs. of steam per square inch reduction in area. Tests were made during a whole month. Condensation losses in steam lines are not included.

"A 55″x60″ simple reversing engine, rolling shapes for a structural mill from ingots, consumed 1054 lbs. of steam per ton rolled, losses in steam lines included.

"A modern 46″x76″x60″ twin-tandem compound engine using 23 lbs. of steam per 1 H. P., rolled 600,000 tons per year. Average steam consumption per ton, including losses in steam lines, was estimated at 600 lbs., being considerably less than has been shown by actual tests made on similar engines. With coal at $5 per ton, the cost of steam would be 39c, auxiliaries included. The cost of power on the same electric driven mill would be 19c, or 20c less than steam cost.

"Costs for steam on old simple steam engine driven mills, amounting up to 75c per ton, are not unusual at all,

where 18c to 25c per ton in electric mills are the average costs."

I have cited the above figures to prove that steam driven mills should not be put in the same class with motor driven mills, when making comparisons in cost of production. Since 1918, nineteen electric reversing mills were installed in the United States and only two steam driven reversing mills. At the same time 56 steam engines have been replaced by motors, while not one steam engine was put in the place of a motor.

There is no doubt that it would be a good paying investment to scrap wasteful steam engines, even with the high fixed charges for interest on investment, depreciation, and taxes. However, this item must not be overlooked, as it is liable to eat up the savings made in the cost of power per ton of steel rolled.

Mill superintendents with long experience can fully appreciate the satisfaction that results from the ability just to throw a switch or push a button and start the operation of a mill. In practically every instance where motors have replaced engines, an appreciable increase in tonnage was noticeable. That electric reversing mill drives can produce as great tonnages as steam drives has been shown at the Bethlehem Works at Sparrows Point, where close to 200 tons of 8″x8″ blooms were rolled per hour from an ingot 21″x43″, weighing 16,500 pounds.

In reviewing Mr. Fox's paper, one cannot help but see that the introduction of electric drives has made it possible to clear up many points in regard to the power requirements for rolling different shapes of steel, and moreover the roller can see at a glance the work done in each pass.

The electric drive has also been instrumental in getting the best relation between rotating masses, time, speed, and horsepower. It has helped the roll designer to calibrate rolls in such a manner that the power requirements for all passes are more uniform, thereby avoiding high power peaks, and at the same time de-

creasing the use of prime-mover first cost and subsequent fuel consumption.

Mr. Fox has shown in his curves that lower heat, greater elongation and especially change of profile in different directions increase power requirements at the rolls much more rapidly than do chemical hardness, high tensile strength, or large draughts. It shows that it is not the higher percentage of carbon or alloys in steel that requires more power in rolling, but the lower temperature at which such steel has to be rolled. For the same reasons, squares and rounds take less power in rolling than shapes with large peripheries and thin flanges, which cool off quickly.

Tests on rail mills have shown that the footpounds per square inch of displacement gradually increase the nearer the rail travels toward the finishing pass. A 75 lb. rail required 1100 footpounds at the first pass in the first rougher; in the seventh pass, 3000; and in the first pass at the second rougher, 4800; in the fifth, 8150; and in the finishing pass, 9500 footpounds.

In conclusion I beg to call your attention to the large saving in non-productive labor made possible today through the use of electrical apparatus which will automatically start and stop machinery when required. Generators, motors driving pumps, fans, elevators, etc., can successfully be operated behind locked doors without any attendant whatsoever. When load conditions demand it, machinery will start automatically and shut down when not needed. In case of trouble, such as hot bearings or windings, alarm is sounded and finally the machinery is automatically shut down before any damage is done.

The Chairman (Mr. W. A. Rogers): Gentlemen, we have listened to some very interesting and instructive papers this afternoon. The gathering this evening is appointed for seven o'clock. This session is adjourned.

DINNER OF THE AMERICAN IRON AND STEEL INSTITUTE IN THE GRAND BALLROOM OF THE COMMODORE, NEW YORK, MAY 23, 1924.

EVENING SESSION

The evening session of the Institute was held in the Grand Ballroom of the Commodore. After dinner, President Gary called the meeting to order.

JUDGE GARY: Gentlemen, you have had two or three hours in which to visit and do your talking; now will you kindly allow others to talk for a few minutes? Remember your reputation which has been established for quiet and close attention, and particularly remember that, if every one in the audience is quiet, every other person can hear all that is said, and there are many who would like to hear from our distinguished guests. We have three this evening, whom I will later introduce.

We have with us Hon. Honorio Pueyrredon, Ambassador of the Argentine to this country; Hon. Donald MacKinnon, Commissioner from the Commonwealth of Australia; Hon. Axel Fredrik Wahlberg, President of the Swedish Iron Masters Association. Later I will tell you something of these gentlemen,—or read it to you.

This morning I talked to the Institute extempore, without any written document. This evening what I will express to you I will read. At the instance of the Committee the speech which was prepared for this morning has been reserved for this evening. It is something that the American Iron and Steel Institute members are entitled to have said concerning their war work during the late great World War, and it will be preserved in the annual records of the Institute.

Gentlemen, these remarks affect you, they are for you: your own record is recounted and will be preserved for the benefit of posterity. Will you kindly give your close attention?

The greatest and most destructive of all wars, to be known as the World War of 1914-18, had been raging for more than two and one-half years with extraordinary and surprising success to the Central Powers, when the Congress of the United States, with practical unanimity, endorsed the declaration of the President that the time had arrived for our Government to mobilize all the military forces and facilities of the country and to utilize them in supporting the allied armies of the Eastern Hemisphere in their contest for the defense and preservation of civilization. Conditions were critical and possible results to the whole world uncertain.

Soon after the United States entered the war, Mr. Bernard Baruch, by appointment and at the direction of the Council of National Defense, called upon the President of the American Iron and Steel Institute and requested him to act as Chairman and to organize a committee of iron and steel masters to represent and to mobilize the iron and steel industry of the United States in co-operating with the Council of National Defense in supplying and utilizing the iron and steel necessary for war purposes up to the full limit of productive capacity. This request was fortified by letters from the Secretary of War and the Secretary of the Navy.

Besides Mr. Baruch wrote:

"I have just communicated by telephone with Hon. Newton D. Baker, Secretary of War, and President of the Council of National Defense, who has requested me to ask you to serve as Chairman of a Committee on Steel and Steel Products, which he trusts you will accept. We would be glad to have you select among your associates such committees or committeemen as you deem wise." . . .

And again:

"I am in receipt of your letter notifying me of the appointment of your committee. I think the country is particularly fortunate in having men of the character and ability of yourself and your associates.

"I presume that, being men of vision, you realize of what great importance your committee is, and also what grave responsibilities

rest upon it and upon each and every member of it. Should the crisis, which I believe is now upon us, come to a head, it is to your industry and the men running it that the country will have to rely, as much as, if not more than, any other, for its protection and defense."

Secretary Daniels wrote:

"I beg to acknowledge receipt with thanks your favor of the 29th instant, advising me of the committee you have selected on steel and steel products. . . . Also a letter to Mr. Baruch giving the names of the committee selected by you as President of the American Iron and Steel Institute, on Steel and Steel Products. I am sure that a committee composed of such men can render most valuable aid to both arms of the service. I am very glad to note that the spirit manifested by the members of the committee was loyal and liberal."

The Secretary of War wrote:

"I have just received your letter of March 30th, informing me that, at a meeting of the Committee of Steel Manufacturers, certain base prices were agreed upon as reasonable. I note that a copy of that letter has been sent to the Secretary of the Navy and one to Mr. Baruch.

"Please permit me to thank you and your associates for the patriotic and liberal consideration given to this most important subject."

In accordance with the request from the Council of National Defense through Mr. Baruch the committee was immediately organized, established sub-committees, commenced active operations, met frequently and remained in office until after the armistice was signed. At first it was designated as a part of the Council of National Defense, but a little later, because of legal questions which were raised, the committee was dissolved, and, at the instance of the Government, its members were promptly organized into a new, independent committee representing only the iron and steel industry of the country.

The members of this committee you know. Their activities, in general, were reported to the Institute at its regular meetings, as will appear by reference to the addresses of the President, printed in the yearly volumes.

How much hard work was done by the general committee and by sub-committees need not be detailed. A

large part of the hard work was performed by the committee on distribution, composed of James A. Farrell, E. A. S. Clarke and J. A. Topping, and their skill, patience, fairness and success are deserving of the highest praise and most generous commendation.

The general committee on steel assumed full charge of the activities of the iron and steel industry relating to war production and intercourse with the different departments of Government. Meetings of the general committee throughout the war were frequent and generally held at the office of the President, Mr. Clarke acting as secretary. But the most important, delicate and involved work of the general committee related to the meetings of this committee from time to time with the leading members of the entire industry engaged in the production of raw, semi-finished and finished materials and transportation of the same, and with the representatives of the Government at Washington. At the beginning, one governmental representative or more would visit the committee in New York for the discussion of prices or other matters; this practice was to some, but not large, extent followed throughout the war. Later the general committee was called to Washington to meet and discuss various questions with the Secretary of War and the Secretary of the Navy and others.

Still later, the War Industries Board was organized by and for the Government, and its meetings were held in Washington. This board had charge for the Government of many questions, including allocations, productions, distributions and especially, because most important, the fixing of selling prices for commodities included. It was this board with whom the general committee of the steel interests usually had contact, discussion and arrangement concerning the steel sold to the Government. In the earlier months there were different men at short periods acting as chairman of the War Industries Board, all good men, but finally Mr Baruch became permanent chairman of the Board, with Mr. Robert

S. Brookings permanent chairman of the Price Fixing Committee, and Mr. J. Leonard Replogle, Director of Steel Supply. There were other sub-committees, but not so active concerning the steel business. The number on the War Industries Board was large and their names are well known. They were able, fair and conscientious. From the viewpoint of the steel industry, Mr. Brookings was the most conspicuous. He was chairman of the committee with whom the steel committee had the most discussion, and, so far as some members of this committee are concerned, the greatest difference at the beginning of the hearings. He had able associates on his committee, but he had a decided advantage over most of them. He had had a wide and valuable experience in business management. He was a very hard worker and, between the meetings with the steel committee, he would become thoroughly familiar with the affairs of the steel men. With the aid of the Federal Trade Commission, in examining and reporting on the books of the producers, he learned the actual costs of production and delivery. Besides, he was an able, intelligent, learned man, president of a college, shrewd, clear, forceful and convincing in expression of his views. He was an entire stranger to the members of the steel committee when they first met him in connection with the War Industries Board, but they soon learned to know him and to respect his conclusions. It is only fair to say that, after a long experience with the War Industries Board, all in all the steel committee could not, nor had any inclination to, challenge the wisdom, fairness and intentions of this Board from Mr. Baruch down. We did not always agree with them. Quite the contrary. Some of us thought at the time some decisions were wrong and unjust, but considering everything, we now believe they were justified in their conclusions.

Prices on all iron and steel commodities were fixed about every three months. Notice of the meetings of the Board were sent to the steel committee in advance. Then,

as some of you well remember, came the necessity for consultation, discussion and, finally, decision. The chairman of the steel committee would send notices to representatives of the entire iron and steel industry for a meeting at a time and place designated. The attendances were large and the discussions were protracted. As a rule, larger selling prices for the three months to follow were urged by many steel men in attendance and good reasons were given; higher costs of production, higher wage rates and transportation rates, higher taxes, additional wear and tear on machinery, much larger prices offered for use in construction outside of military purposes, foreign and domestic, inability on the part of many to furnish material up to the allotments, etc., etc. Much patience had to be exercised by everyone. For purposes of the record, reference will later be made to the attitude assumed by the general committee on steel.

The general committee stood for what its members believed was fair, no more and no less. At some meetings of the entire industry there were many manufacturers who seemed to think the steel committee was not reasonable in respect to giving advice, particularly towards producers whose costs were high. In several such cases certain members of the steel committee purchased from the complaining producer and personally paid for his or its commodity at prices materially larger than the Government prices.

As the result of these frequent representative steel meetings, it is believed that, without exception, it was, before final adjournment of each meeting, unanimously resolved that the whole subject matter be submitted with full power to the general committee. This was not only creditable, it was astonishing, for the arguments in favor of prices lower than some that were demanded were made by members of this general steel committee. Among the arguments advanced by those who advocated the lower prices, the most telling and convincing related to patriotism, love of country and duty. Not a man in the whole

steel industry who attended these meetings ever did or ever could ignore or resist the influence of appeals to his spirit of loyalty. Looking back to these meetings of excitement, sometimes of apparent temper, deep-seated and well expressed sentiments of dissatisfaction and injured feelings, allow your President to say that the grandest and most satisfying experiences in his life were to see large numbers of steel magnates stand upon their feet again and again as an expression of assent to resolutions in favor of subordinating personal interest to the public weal. All credit and honor to these men.

But the difficulties surrounding the steel committee were not ended with the adjournments of the large meetings of the steel industrials. The subject matter was referred with power to the committee for action, and composing this committee were ten members. They were hardly ever entirely in accord at the beginning. There were many discussions and occasionally wide differences. Often decisions were not reached by them in time to meet the Industries Board in Washington, as notified, and further time to consider and report was asked and granted. More than once, the general committee, without having agreed, met the Industries Board, and different schedules were presented and discussed. In such cases the War Industries Board had to adjust the existing differences. Having said this much, only for the purpose of hinting at the difficulties which perplexed the steel committee, it is proper to say that there is no good ground for finding fault with any member of the committee. All were fair, well-intentioned and intelligent. Perhaps everyone was right from his own viewpoint. There was never any ill-feeling among the members of the general committee. The chairman has reason to be grateful for the splendid assistance rendered by every other member of the committee.

Nor did the members of the War Industries Board always agree at the start, judging by their remarks and discussions. They had their troubles. However, at the

end of every hearing, after much discussion, wide differences, consideration of what seemed insurmountable obstacles, both sides, the War Industries Board and the general steel committee, unanimously agreed upon prices for three months, and the President approved and published the prices fixed. This also was largely influenced by a spirit of patriotism.

As to profits based on these prices, they were nil in some cases, small in many cases, substantial in other cases and liberal in a few. This was because the only practical and legal thing to do was to fix one price for each commodity, and as no two producers had exactly the same costs, these difficulties were overcome, so far as practicable, by discriminations concerning allotments, by accommodating so far as possible the higher cost mills, and by assumption of certain burdens by those who were better able financially to carry them, and by purchases, as already mentioned.

The iron and steel industry would not like to go through another war, but if it became necessary, would again offer its services and its facilities in defense of home and country. Indeed by resolution of the Institute, lately adopted, it is pledged to do this.

What did the iron and steel industry do or furnish to the United States Government and its associates in the war for military purposes during the late war?

A single industrial concern of this country during the war furnished for the military necessities of the United States and associates in the war, finished steel aggregating approximately 18,500,000 tons, valued at $1,400,000,000. It purchased Government Liberty and Victory Loan issues amounting to about $112,000,000; expended for extensions to producing plants and other property in order to enable it to meet the demands for steel and proprietary products a total of about $350,000,000. We rightly assume that other business concerns engaged in the same line of industry together supplied steel to relatively the same extent and made proportionate expenditures and

investments; and therefore there was furnished by the industry as a whole at least 35,000,000 tons of steel of a value of $2,600,000,000, and an outlay for expenditures and investments of $750,000,000 or more.

Besides this, without any demand or request from the Government or from the workmen, it increased the wage rates from time to time, commencing with an average daily earnings per employe of about $2.85 in 1914, until they amounted to an average of $6.20 in December, 1918, an increase of 117 per cent.

It furnished to the Government, without charge or recompense, large numbers of experts in various lines of the nation's military activities.

It extended its capacity to produce finished steel products by about 10,000,000 tons per year, in many cases for works that could not be utilized in times of peace and therefore were nearly a total loss.

It never refused nor neglected to honor any requisition of the Government for any expenditure deemed essential to carrying on the war.

It expended for experimentation millions of dollars in order to assist the Government in its endeavor to perfect its facilities for military defense.

It never failed to make deliveries of steel or finished products demanded for war purposes and, on the contrary, met every demand, and without any delay that was injurious to the Government or materially interfered with its war program.

In every respect it gave its unlimited, unqualified support to the Government and its associates in their military campaigns up to the full measure of the capacity which it possessed at the beginning or could secure by prompt and efficient effort and expenditure.

And everything it did was done cheerfully and promptly.

At one of the meetings in Washington, probably during the fall of 1917 or the early part of 1918, it was stated by Mr. Willard, the then acting chairman of the War

Industries Board, that the Government was seriously considering the desirability of taking over the control and management of the total iron and steel industry of the United States as a guaranty of full production and distribution. This provoked expressions of surprise and objection, whereupon Mr. Willard, for his Board, promised that before action of this kind should be decided upon, the steel committee would be duly notified and given a full hearing. Subsequently the steel committee received notice to appear before the War Industries Board in Washington, at a time fixed in the notice, for consideration and decision of the subject of taking over the iron and steel business, as previously suggested. The committee appeared and a somewhat lengthy discussion took place. Several members of the Board argued in favor, and members of the steel committee against. The chairman, with earnestness and considerable feeling, though with no show of anger, spoke at length. Perhaps the same is true of other members of the committee. After referring, considerably in detail, to what the steel industry, under existing management, had done and was doing towards supplying steel for the military necessities of the United States and its associates, the argument of the chairman of the committee closed with substantially these words: "Gentlemen, if you think, under Government management, better service will be rendered and you believe you can legally do it, you may undertake to forcibly secure the management of the steel business. You will never do it with the consent or approval of the owners of these properties and you will be held responsible, morally at least." Mr. Baruch at this time was chairman of the Board and through Mr. Brookings, who had never advocated the proposed procedure, the Board then took the matter to the President, who, after reading the proceedings written up, decided to let the matter rest temporarily at least. The subject was never again broached to the steel committee. It has been reported that the Secretary of the Treasury had urged the Presi-

dent to take over the steel industry, though the steel committee does not claim to have knowledge of this action on the part of the Secretary. It is believed that the War Industries Board or the Council of National Defense did not originate or advocate the proposed governmental management and control. That the President was urged by some one and was partly committed to the scheme, and that the War Industries Board was honestly advocating the course suggested under instructions from the President, there can be little doubt. Imagine what would have been the consequences if the steel business had been taken over. It is believed this, together with certain labor questions (not including rates of compensation), were the only serious matters concerning which the steel industry was opposed to requests made by any governmental agency during the war.

As typical of the attitude of the steel industry during the war, excerpts from contemporaneous printed records are appended hereto.

Annual Meeting American Iron and Steel Institute, May 25, 1917. Taken from address by the President:

"At last war was forced upon us. The President was compelled to conclude that we were intentionally attacked, that the honor and integrity of our country could no longer be maintained unless the gauge of battle was accepted; and in this decision he was supported by the whole country. His clear, powerful, convincing and eloquent statement of the case and impeachment of the enemy will stand out in history as one of the greatest official declarations and also as fully justified by the existing facts and circumstances.

* * * * * *

"The task which confronts the country is not confined to the army and navy, although they will be entitled to the larger part of the credit and glory if we succeed. They offer their bodies as a sacrifice, and they must have the undivided, unqualified support of all outside their ranks. The time, money and prayers of all civilians must be given for the soldiers. They bear the brunt; they are the shield for our safety. All of us are fighting in self-defense. This is our land and the flag is ours. The ad-

ministrators of the country, from President Wilson down, are no more interested than each of us. Life would not be worth living if our flag were to be permanently furled; if our country were subjugated by an alien enemy, especially such a one as we now defend ourselves against.

"The pecuniary burdens to be imposed upon us will be very great. We knew in advance such would be the case. We must pay the enormous cost of mobilizing, equipping, supplying and moving our own armies; and we must advance money and provide supplies to our Allies in accordance with their necessities and our resources. We could not decline if we were disposed, for they are now fighting our battles and we are, with them, under the whole burden. We must never falter nor retrace our steps. Wherever or whenever the end is we must press forward with all our strength, might, minds and souls. The more vigorously we proceed within the limits of intelligence, the sooner will the end be reached."

Semi-annual Meeting of American Iron and Steel Institute, October 26, 1917. From address of the President:

"If the members of the Iron and Steel Institute agree with what has been said thus far, as from a long and intimate acquaintanceship I believe they do, then it is easy to determine and to follow the lines of duty. We occupy a position of the highest importance in the present war. Our country and its Allies in the international conflict are in need of every pound of steel that can be produced in this country and which can be used for war purposes. To insure this supply, every furnace and mill having relation to the subject must, without interruption, produce to the fullest capacity and subject to the control of the Government through its lawfully constituted agencies. No excuse for neglect, delay or interruption will or can be accepted by the Government. The administration desires and intends to pay fair and reasonable compensation, sufficient to maintain existing wage rates, salaries of officials and extensions necessary for war purposes. Up to the present time we have no reason to complain of the attitude and action of the Government, although we may have been disappointed in some respects. It is up to us to prove our continued loyalty to the Government; but, more than that, our loyalty to ourselves in the performance of duty. Even though there should be dissatisfaction concerning prices or the details relating to production or distribution of tonnage, still production and deliveries must continue without interruption or diminution, leaving any question at issue to be settled at a later date. So long as the attitude of those in control of governmental affairs towards producers remains as it is at present, it must be our effort, as it will be our

pleasure, to do our part unselfishly, wholeheartedly and assiduously.

"If our country is defeated in the pending military conflict your property and business and mine will be of little value. We will have retraced our national steps a century and a half. The wealth of the country would be seized and retained as prize money by other nations. We have been forced into the war and we are compelled to fight in defense of our persons, our property and our sacred honor. There is no escape. We are in the war to the end, however costly and bitter. No man, no country was ever engaged in a more righteous cause or a more compulsory defense. If we do not do everything practicable to uphold the hands of the President and to add to the success of the defense against the foreign aggressor we are less than men; we are weaklings; we are poltroons. I believed for a long time we could and would be kept out of the war, but it was impossible. The President delayed as long as he consistently could. We must now fight with every weapon within our reach. We must liberally subscribe to the Liberty Loans. We must cheerfully pay our taxes, and, of still greater importance, we must furnish steel in larger and still larger quantities."

Stockholders' Annual Meeting, United States Steel Corporation, April 15, 1918. From remarks of the Chairman:

"And at the present time, gentlemen, our works are largely turned over to the service of the Government of the United States. It might not look well for me to give you figures or to tell you in detail what we are doing, but I should be very glad to have you inquire of any Department in Washington with whom we are doing business as to how we are serving the Government at this time. And I would like to have you ask whether or not we are of real benefit to the Government of the United States in this time of crisis. You can get the facts and figures. If you will ask the Secretary of the Navy, the Secretary of War, the head of the Shipping Board, the Chief of the War Industries Board, the Fuel Commissioner, the Food Commissioner, any one of those Departments in Washington with whom we are in daily contact, you can get the facts, and I have no hesitation in referring you to them for testimony as to what we are doing.

"Now, our expenditures have been very large. One of the gentlemen asked a question which brought out this idea. We are spending something like thirteen or fourteen million dollars a month on improvements, mostly for war purposes. The Government of the United States never comes to our corporation with a request that we increase our capacity for steel in any particular line which is absolutely necessary for the military purposes of the

Government, without our commencing immediately to make the extensions required, and that notwithstanding the cost of extensions at this time is two or two and a half times the normal."

General Steel Meeting, April 26, 1918. From remarks of the Chairman:

"Gentlemen, this is an important meeting. It is a patriotic meeting. The steelmakers are called together to consider very important matters, at a time and under conditions which are somewhat critical. We have come together to counsel with one another. It is unnecessary to emphasize the fact that the Allies engaged in the Battle of all Ages are calling upon this country for all the help that can be given. The Allies themselves are doing everything possible to provide the essentials for war purposes, but they are still lacking in the quantities necessary. And this country is therefore called upon to furnish more and more steel and more and more men and supplies of all kinds that are requisite under the conditions which obtain on the battle lines. They need more men, more food, more munitions of war, more guns, and various other things, and ships to carry them across the seas when needed. And all these things must be provided at the very earliest moment. The furnishing of necessary supplies promptly means the saving of millions of lives. So far as I am personally concerned, while I have great hopes for the future and a feeling of grim determination to win this war, yet I have a feeling of fear for catastrophes, a fear for results that we cannot recover from. And that arises not from the fact that we have not enough men or money or materials, but rather from the fact that there is danger that these will not be provided as promptly as they might be and as appears to be absolutely necessary if we are to do everything we ought to do and that we can do.

"I feel it is not necessary in talking to Americans to deal in language of patriotism or duty. Many of your boys and your relatives and your friends are already on the battle lines or on their way to those places, and more and more will be called and are going. And the more diligent we are in the performance of our duty the less will be the number that are called upon to make the supreme sacrifice which war, and war alone, asks of the people, of the country.

"Gentlemen, we are here today to consider whether or not we can do more in providing the requisites for winning the war. We have a general committee representing the iron and steel industry, which means you, and that has a subcommittee of distribution and other subcommittees; and all have been very diligent in attending meetings, in ascertaining facts and figures, in securing data as to capacity and as to shipments, and generally in regard to the details of the business of different lines of manufacture. We all recognize that one of the first essentials is steel, that it is almost as important as food; that the soldier can do nothing

without steel, and that nothing can be taken to the soldiers except by the use of steel. And we have been endeavoring to ascertain what more if anything could be done, what negligence if any there has been with respect to the performance of duty up to the full measure by any of the manufacturers. We believe that more can be done.

"When the Committee ascertains that the total capacity of the country is being used for the benefit of the military, and that it is insufficient, then we are willing to increase capacity. But that requires a good deal of time. The building of a mill or a furnace occupies too much time, except as a last resort in the endeavor to furnish supplies. It is obvious that every furnace, every mill, every facility for production must be used for the purpose of carrying on the war. And in this connection that war's necessities must always be at the top and in front, that non-essentials must be dominated by military necessities, non-essentials of all kinds and in every particular must be subservient. If the mills need more pig iron, pig iron must not be utilized for non-essentials until the military necessities are fully supplied. And the same is true of ore; and the same is true from the pig iron down to the finished product which the Government needs. The question of making money, while always important and necessary for the nation, is of no importance when compared to the immediate necessities of the Government for the production and delivery of the things which it demands and finds necessary for military purposes.

"Therefore our whole business must be managed in such a way as to secure the best results for the Government, even though at times at the expense of production in some lines less essential and the making of money for the owners' property.

* * * * * *

"And so, gentlemen, we have called you together today, not for the purpose of attempting to lecture, not for the purpose of telling you what your duty is—because you know that—but rather for the purpose of expressing in a few words the situation as we see it, and with the expectation that today we shall hear from you representative men who are in control of these lines of manufacture so necessary, an expression of what you think in regard to the situation, which expression should amount to a pledge all of us must give, that we will devote our works, our time and our money, as requested by the United States Government, to aid in this time of extremity.

* * * * * *

"Gentlemen, it is our work. These needs are our needs. This is our Government. We are asking for this steel for ourselves, for the protection of ourselves and our boys and our friends and our business. We cannot agree to the proposition of Mr. Replogle, although it was only stating literally the situation, that the

Government is on one side of the table and we are on the other. We have got just as much responsibility and just as much duty concerning this whole thing as anyone, and we are not doing something because we are required to do it; it is our business and our duty, and we must not neglect anything, because we are protecting ourselves. But I think this already has been emphasized. I am very much pleased with some of the remarks made here today. I thought Mr. Verity's speech was very strong. He put the situation from the standpoint of duty and patriotism which rested upon each of us as individuals. I think the action of everyone here today makes a record that we all of us ought to be proud of.

"During the time I have been connected with the steel industry, during the period it has been my pleasure to be closely associated with steel men, from time to time I have been proud of their attitude, their fairness, the feeling of justice, the disposition to co-operate and help one another, to serve one another, and to serve the public, and to serve the country, and to serve every interest that depends upon their action. And today we see another exhibition of the bigness of the men who control the steel industry. There is not any room left for criticism.

"Someone remarked that the steel men generally had been more patriotic and more prompt in their service than other lines of industry sometimes. Today we are setting an example, we are establishing standards of propriety and right and justice and patriotism; and this influence spreads, others hear of it, and you may be certain—at least, I am certain from the information that I have received from time to time—that Mr. Replogle is not slow in presenting your interests, and not only that, your disposition, your efforts in favor of the Government, to whomsoever he meets who is interested in our affairs and business under his charge. That is bound to spread. And, gentlemen, we have done something today we may be proud of, provided we live up to our pledge."

After discussion, the following pledge was offered for consideration and decision by those present:

"For myself, my corporation or my firm, I pledge the prompt production and delivery of the largest possible quantity of material in our departments that is or shall be required by the United States Government for the necessities of itself and its allies, and agree that all other lines of our business shall be subordinated to this pledge, and all this in accordance with the request of the War Industries Board."

After many addresses in favor of the pledge proposed by the Chairman, it was unanimously accepted and agreed to.

Annual Meeting of American Iron and Steel Institute, May 31, 1918. From address of the President:

"The steel industry is doing much to assist in this war. The American Iron and Steel Institute has been carrying on a very large work. It is in close communication with the Governmental officials day by day. It is a means for securing and distributing information to the Government officials. It is the agency upon which the Government depends very largely for assistance in carrying on many of the activities essential to the war.

"Some of you know and some of you do not know that the staff of the Institute has been very largely increased, that the office room has been extended, and that Mr. McCleary and his faithful associates and assistants are devoting long hours in securing and furnishing to the Government such aid as it needs and calls for. The Institute under this management is a credit to all of us, and it is of real value to the Government—to the general public. It has approached the position which eight years ago we all hoped it might in the course of time reach. We may well be proud of the fact that we decided to form this Institute, and that we have so faithfully stood by it.

"The general committee, appointed by the directors of the Institute, have been doing valiant service. They have been devoting a great deal of time; they are giving all the affairs submitted to their charge, by direction of the Secretary of War, the Secretary of the Navy and the War Industries Board, their best thought and their energies in an endeavor to serve the Government faithfully and at the same time to protect the interests of the whole steel fraternity of this country. In referring to these matters I intend to exclude myself. It is a matter of gratification and it should be of peculiar pride to all the members of the Institute that they have such a general committee, well disposed, well trained, and well fitted to carry on this very great work.

"And the subcommittees have all been rendering splendid service. You are familiar with the different committees. Some of you are not acquainted with their work in detail, and you would be surprised to know, perhaps, that many of these gentlemen also work from early in the morning until late in the evening; and they are laboring with very great satisfaction to all who know what they are doing and who are depending upon them. It has been a source of pride to me when I have noted the results. Too much praise cannot be given to them for their willingness, patriotism, and at the same time their loyalty to the industry. I am quite sure that all the manufacturers ought to be very well satisfied with what is being done for them by a comparatively few individuals."

Judge Gary: Gentlemen, you never failed, you never faltered, you never gave occasion for complaint, and you are to be congratulated, your descendants are entitled to

know on the records of the Institute what you did and what you were during the great war which came near overwhelming the world (applause).

Gentlemen, please observe order. You are going to hear some speeches worth listening to. Please do not leave the room, unless you find it absolutely necessary to make a train.

I have had compiled for me by those competent to do it, largely from published records, a slight history of the speakers whom you will have the pleasure of listening to.

The first is His Excellency, Ambassador of Argentine, Dr. Honorio Pueyrredon: Born July 9, 1872, son of Doctor Adolfo Pueyrredon and Dona Maria Idalina C. de Fontours de Pueyrredon, the family name being long honored in Argentine; Don Juan Martin Pueyrredon, great, great uncle of the Ambassador, having been President of the Nation in 1819, even before the Republic, strictly speaking, was established.

The Ambassador was educated by tutors until he entered the University of Buenos Aires to study law, doctor's degree being conferred on him in 1896. He was appointed shortly thereafter to an instructorship in the law school, and later elected to the University Council, indicating the brilliancy of his University career and the esteem of his colleagues. He is author of a notable work on Civil Procedure. Later he devoted himself to the study and management of his extensive ranch and rural property.

In 1916, when Dr. Hipolito Yrigoyen became President of the Republic, Dr. Pueyrredon accepted appointment as Minister of Agriculture, to which was added, a short time later, the difficult portfolio of Foreign Affairs. In the six years during which he conducted these two most important departments of the Government, many delicate problems demanded attention. In foreign relations, he had the threatened war with Germany, sinking of Argentine vessels, the Luxburg affair and many other serious matters.

Dr. Pueyrredon has represented his country at the following international gatherings: Conference on Maritime Law, held in Venice in 1911; the Centenary of the Battle of Maipu, celebrated in Chile in 1917; the first assembly of the League of Nations at Geneva in 1920, in which he headed the Argentine delegation and was elected one of the League's Vice-Presidents. He presented his credentials to President Coolidge in the White House, March 10, 1924, as Ambassador of Argentine Republic.

I now have the very great pleasure of introducing you to this very distinguished man, His Excellency, Dr. Honorio Pueyrredon. (Applause.)

Dr. Honorio Pueyrredon: Mr. President and Gentlemen: You will excuse, sir, my poor English; I am really afraid to speak in English, but you would be more afraid should I speak in Spanish. I think you will prefer then my bad English to my good Spanish.

I present the homage of my consideration to this great Institute which does me the honor to have me as its guest.

The name Iron and Steel Institute contains the magic words that revolutionize and galvanize modern civilization. Its destinies are directed by Judge Gary, an eminent lawyer, which fact suggests the reassuring thought that force must be always directed by right.

After three centuries of struggle the iron industry in England continued in its infancy, and in Germany Essen was a small agricultural hamlet. The Puritans, on this side of the water, were the first to produce as much as 14,000 pounds of iron per week. The initial efforts in America were a prey to Indian barbarism that made of the miners the first martyrs of American industry. For five generations that industry carried on an heroic struggle against the savages, until, indeed, what may be called the aristocratic period opened, in which American iron was purchased by Louis XV, Queen Anne and other high personages of European courts.

But it was not the favor of monarchs nor the patronage of princes that determined its development. It was

the American revolution that gave to the iron and steel industry its strongest impulse, thus confirming the idea that it was predestined to serve above all the ideals of democracy.

The famous chain, a mile in length and 200 tons in weight, that was stretched across the Hudson at West Point to prevent an attack by the British squadron, was the first triumph of the emancipating power of iron.

Thus, it was only after the Independence was consecrated and the Civil War had confirmed the internal autonomy of the country, that the manufacture of iron in the United States entered upon its period of great progress; that the discovery of new mines changed the industrial map of the United States and moved the commercial center of iron and steel from the Ohio river to the regions of the Great Lakes; that new cities arose out of the plains; that great railroad lines gridironed the territory; that discoveries such as those of Kelly and Bessemer produced a revolution in the production of steel, and, finally, that the iron and steel industry of the United States stood forth triumphant at the head of the world's production.

The sociological fact of the Independence thus produced its economical effects. It is evident that the industry only achieved its development in the broad field of liberty on which the struggle with its fellows opened—in an atmosphere that has stimulated and given it strength.

But when the industrial production and economic potentiality of a nation has reached the stage at which its own needs are filled, one of the most complicated of collective problems is created. It cannot stand still, for in industrial life not to advance is to go backward; neither can the energies created by that same advance be arrested. Both require new channels, because, as in the case of the damming of a torrent, the overflow is dangerous. But those new channels are generally to be found abroad. They cannot, however, be secured by artificial means. The placing of the surplus product in foreign

DINNER OF THE AMERICAN IRON AND STEEL INSTITUTE IN THE GRAND BALLROOM OF THE COMMODORE, NEW YORK, MAY 23, 1924.

markets, at even lower prices than are paid by home consumers, is a false economic principle which afterwards causes an unsound increase of prices that is bound to become a source of serious internal conflicts.

The solution lies in the classic expression, "interchange"; but interchange means reciprocity. This can be graphically illustrated by folding doors, of which one cannot be opened without opening both. The policy that seeks to level up by taxation the cost of production of foreign raw material and foodstuffs, thereby restricting their importation, necessarily produces two other effects; it reduces exportation, and impedes the lowering of the cost of living; and this, in its turn, makes more difficult industrial competition with other countries, which countries, having none of these drawbacks, produce more cheaply.

The world is marching towards what we may call economical defrontierization, with the purpose of facilitating free communication among nations and assuring the harmony and welfare of peoples.

"International community" must cease to be a mere phrase and become a reality if we would have the world peopled by human beings and not hostile, rival entities which will gradually create antagonisms that must eventually clash in some great cataclysm.

The Americas have organized a system of life—Pan Americanism—that has for its purpose that very community. It has already produced some fruit. It has brought about substantial approachments and has labored without sparing of effort; but its activities will never be completely effective if its work is stopped by the measures which, mindful only of momentary interest, fail to achieve the high purpose of the institution.

Not long ago I had the honor to preside in Buenos Aires, as Secretary of State, over the Inter-American Congress which decided to reduce the external postal tariff to the level of the internal rate. That action was transcendental, because it established a principle: that is

to say, the sacrifice of material interest in favor of intercommunal friendship among countries, facility in the transmission of the written word, which conveys thought, disseminates ideas, and, in their wake, follow men and things to mingle among peoples.

If Pan Americanism is frustrated by acts that impede such intercourse, it will become less and less effective. The measures adopted by its congress will become mere abstract formulas that can serve but to enrich international literature. That is to say, we shall have failed. But for such failure the governments will not be responsible. In modern democracy, they are the people who rule and the governments who merely execute their will.

Gentlemen, you are the true exponents of the gigantic progress achieved in this country by iron and steel. I well understand that your potentiality needs other fields for its development.

In your hands, then, lies the opportunity to rebuild that historic chain, not with the purpose of preventing the entrance of anyone, but to link together the two ends of the "new world" (applause).

JUDGE GARY: The Hon. Donald MacKinnon, Commissioner for Australia to the United States, was born in Victoria, Australia, member of a pioneer Scotch family in that state; educated at Geelong Grammar School, Melbourne University and New College, Oxford (England). Member of the English and Australian bars. Gave up his profession for a political career, became a recognized authority on drafting parliamentary bills; was over twenty years in Victorian Parliament; held office as Attorney General, Solicitor General, Minister of Railways, Director General of Recruiting for Australia during the great war, and Minister in Charge of Soldiers' Land Settlement, in Victoria, after the war. Trustee for many large estates and Chairman of the Equity Trustees Company. Interested in athletic sports and for sixteen years

President of the Victorian Cricket Association. Largely interested in well-known pastoral properties in Victoria, New South Wales and Queensland.

I now have the honor of introducing to you the Hon. Donald MacKinnon. (Applause.)

Hon. Donald MacKinnon: Mr. President and gentlemen: I am sure we all listened to my predecessor and congratulate him on being able to speak our language so well. When I say our language, I am reminded of the last meeting I had with a rather well known man in my country, who is here at the present moment in New York, Mr. William Morris Hughes. When I was coming here last year, I met him on one of the streets of Sydney the day before I sailed. He said, "I hear you are going to America." I said, "Yes." He said, "You will have to go to the Berlitz School." I said, "Why?" He said, "To learn American."

Well, I found I did not have to go to the Berlitz School; I found no difficulty in making myself more or less intelligible, so far as the language is concerned, to the delightful American people whom I have had the pleasure of meeting during the last eleven months.

I appreciate more than I can express the high compliment which the members of this Institute have paid my country and me in asking me to be present at this annual gathering. I have been long enough here to know what counts and I am well aware of the importance of the vast industry with which you gentlemen are associated.

Some years ago in our moments of national self-satisfaction we used to call Australia God's own country. I fancy New Zealand appropriated the trade description first; perhaps because they are nearer America. Then came the caustic British critic saying, "These Australians are both vulgar and unoriginal and the best they can do for themselves is to try and annex for their country a phrase which was invented by American bagmen for a description of the United States." And so we have allowed this vainglorious plagiarism to pass into the

limbo of things we would rather have expressed differently.

Now I am going to call this great Republic with its progress, its vast enterprises, the Cyclopean scale of its endeavors, its huge cities and its lofty buildings, I am going to call this a country owned by gods, for nowhere in the world does the genius of man in its triumph over nature so boldly manifest itself; nowhere is the strength and vigor of the human race so obvious in outward and visible signs. This line of thought came to me during the course of a recent week-end expedition; I had to go to Washington and to go from there to Pittsburgh. It was a damp day and after I and my Australian friends had visited Mount Vernon we drove in the receding daylight through the beautiful and impressive field at Arlington where your country has created the earthly home of this nation's heroic dead. Among these silent records of those whose valor has defended their country's honor, beside the noble memorial, passing the resting place of the unknown soldier, member of an army which defended not only your country but the safety of civilization, which splendid service we Australians gratefully acknowledge, in the gloom of a damp and diminishing day, one felt oneself to be in an earthly walhalla. The next day I went on to Pittsburgh. Americans, I venture to think, mislead a stranger by their comments on this famous centre of your mighty industry. I had formed in my mind the vision of a coarse and dirty town living under a cloud of grimy smoke, a sort of cross between Sheffield in England and London in December fog.

Here again was reproduced the impression of man's godlike control over the forces of nature. By the courtesy of your distinguished member, Mr. James A. Farrell, I was enabled to visit one of the iron and steel works. What I saw there is familiar to all of you; it is the throne of the great God Vulcan, Vulcan who lately has co-operated with Mars, the God of War, and will co-operate again unless the people who cherish real peace,

as Australians and Americans do, set their faces against this unholy alliance. I need not enter into a description; enough for me that I came away with fresh hope for the development of my own country, based on the latent gifts of nature and the might of capital and industry capably directed.

You might endure with the patience which is characteristic of Americans, a few remarks on the state and prospect of this elemental industry in Australia. I am told a few words would be acceptable.

Looking at the question from this side of the Pacific the trade figures show that while we do not take much directly in steel and iron, we are your customers in a considerable way for these products in a manufactured state. Since I came here, some 11 months ago, I have drawn attention to the volume, expansion, and one-sided nature of this country's trade with my country. I hope my figures do some good. Perhaps they are missing fire. Here are the figures for five recent years:

	1917-18	1918-19	1919-20	1920-1921	1921-22
	$	$	$	$	$
Total.....	77,280,000	135,915,000	119,000,000	180,000,000	94,000,000
Machinery and other.	26,500,000	42,000,000	41,000,000	65,500,000	35,000,000

You will see that these are considerable figures for export trade with a country which has less than 6,000,000 inhabitants. Please note that roughly one-third of these sums are in products which consist mainly of iron and steel.

This you can't get away from, namely, that we are your best customer for automobiles, especially for the chassis: also we take large quantities of tools of trade and other machinery. These things are iron and steel in another shape. But this is only the beginning of our market. We have a country larger than the U. S. A. in area. The popular notion that it is largely a desert would not stand examination. No country in the world is so rapidly responsive to the industry and contrivance of man. Its riddle is one easily read. Now take one line alone which

is essential, namely, railroads. We have some 26,000 miles of single track: you have over 260,000 miles in an area slightly smaller than ours. Before your Civil War, when Lincoln became your President, you had 30,000 miles. We have no Mississippi Valley. There is only one in the world. But we have a soil of rare fertility and we have a climate which suits man and beast better than any other in the world. All that is required is transport. So that you see what a vast field is being made available for the iron and steel industry in this new land.

You will say what are the local conditions of the industry. Well, we have the raw materials. There is abundant coal; for obvious reasons, only the coal measures on the coast line have been opened up. We have rich iron ore in many places. Limestone is abundant. Molybdenite and other minerals that are useful in your processes are amply supplied.

You will ask what is being done locally to turn these supplies to use. What iron and steel works have we got? Well, I feel like the man who had to write an essay on "Snakes in Ireland" and began "There are no snakes in Ireland." This would be hardly true of steel works in Australia. For a people with a small local market we have made a brave beginning. At a place called Lithgow, in New South Wales, there has been a works for some years operating with varying fortunes. Recently the Broken Hill Proprietary Mine have erected three blast furnaces at Newcastle in New South Wales, and are doing a considerable business. They draw their iron ore from a rich field called Iron Knob in South Australia, and their limestone from the north coast of Tasmania. In both cases they have suitable water carriage. This is only the beginning of an industry. It receives every encouragement, by way of tariff and preference in public contracts, that can be given to it. American, if I remember rightly, Pittsburgh, experts were employed in starting these works, and doubtless it is the foundation of a great industry.

I am afraid this is not a long story. As the poet says, "the short but simple annals of the poor." But Australia will grow. She is worthy of your attention. What I would particularly like to see would be more Americans coming to our country as tourists or business men. We are on the way nowhere, it is true, but I think, in many ways, are worthy of a visit for our own sake. We shall make you very welcome. (Applause.)

Judge Gary: Mr. Axel Fredrik Wahlberg, graduate of the Technical High School in Stockholm, started as metallurgical engineer and manager of blast furnaces and converters at Sandviken, was organizer and first President of the Royal Testing Institution and at the same time Professor at the Royal Technical High School in Stockholm. During this period, he collaborated with Brinell in developing standards of heat treatment and hardness, and prepared the reports for the publication of these results.

In 1903, he succeeded Brinell as General Manager of Fagersta Steel Works, and resigned to take the position of technical head of the Jernkontoret (Swedish Iron Masters' Association), which was founded in 1747 as an association to extend financial support to the many hundred small iron works during periods of unfavorable business. This was at the epoch when Sweden was, in tonnage, the largest iron producer in the world.

This association has no shares, distributes no profits and its organization was and still is under Government auspices and operates without payment of any tax. The funds were raised by annual subscriptions based upon tonnage output at the time of subscription and works are still members on the basis of original subscriptions made more than one hundred years ago.

Early in the nineteenth century, the Jernkontoret ceased to use all its resources for financial aid and appointed a staff of engineers, who were at the call of all

members to give technical advice in the erection, equipment or operation of their works.

In 1817 it began the publication of the *Jernkontoret Annaler,* which has been published without interruption and is the oldest technical journal in the world.

The Jernkontoret appropriates funds for half the maintenance of two special metallurgical technical schools, several schools for educating skilled workmen in the processes for the production of charcoal, and for advancing funds to enable graduated engineers, as well as foremen, selected for ability, to enable them to visit foreign countries for the study of special developments in the making of iron and steel.

It has led the development of metallurgical research work in Sweden. In the middle of the last century it appropriated funds for developing, in collaboration with Sir Henry Bessemer, the first plant in Sweden for making high-grade Bessemer ingots, and erected about 1908 or 1909 the first plant in the world for producing charcoal pig iron with electricity.

Since 1903 it has been appointing a chief technical adviser, who especially handles the many questions which in these times cause friction between Government departments and the industry as a whole—such as taxation, tariff, treaties with foreign countries and similar matters of common interest. The first man appointed for this part was Brinell, and Mr. Wahlberg succeeded him in 1914.

It is my pleasure to introduce to you Mr. Axel Fredrik Wahlberg. (Applause.)

Mr. Axel Fredrik Wahlberg: Mr. President and Gentlemen: For your very cordial reception here, and especially for the words that Judge Gary has been speaking about me and the old Swedish institution, I here wish to express my most sincere thanks. I am very glad indeed to have this opportunity to tell you how highly we esteem Judge Gary in Sweden. Judge Gary is the most noted world-known leader of the iron and steel industry

of the present time. We always, in Sweden, read his addresses and follow his doings with the greatest interest; and I dare say that we consider Judge Gary more or less as the one and only correct barometer for the business in America. (Applause.)

I suppose that you may expect me to say something about the present situation in Europe. But this I am *not* going to do, simply because you, here in America, know just as much, or as little, about it as we do on the other side of the water, and I expect that we all agree upon the impossibility for Europe to get a clean bill of health as long as the present policy prevails there. However, I will take up a few minutes of your time to tell you some things about my own country that may be of interest.

In more than one way Sweden came out of the World War crisis comparatively well. Our financial position is considered good, and our money is one of the few European currencies that ever since the war has kept at par with the American dollar.

Nevertheless, Sweden has suffered greatly and is still suffering from the consequences of the world's disaster. At the end of the war period our industry was more or less overcapitalized and in many cases too heavily loaded with debts accumulated when we were enlarging our factories to an extent which, since the boom subsided, proved of little or no use. The result has been a serious drop in nearly all industrial stocks and shares. Naturally this has made difficulties for the Swedish banks, which, however, have weathered the storm better than was anticipated.

The years 1921 and 1922 were especially severe for the Swedish industry, but last year things began to pick up a little and at the present time unemployment in Sweden is not greater than it was in normal pre-war times.

But we still have difficulties in making ends meet; this

principally on account of too high wages and labor troubles.

Regarding the Swedish iron and steel industry, I dare say that our difficulties have been particularly great, and are so still. As I suppose most of you gentlemen know, this industry is based largely on export to foreign countries and, considering that we actually have, so to speak, lost some of the most important of these markets, such as Russia, Germany and Austria, whereas most of the remaining are not at all what they used to be, it is not surprising then that conditions still are bad enough.

As to our American market for high-grade iron and steel, I am happy to state that there is still a demand for our products. I regret my inability to give you accurate figures concerning what America has been buying during the latest years; but, before the war, I believe our steel export to this country never exceeded 10,000 tons per year. Besides this, we used to export some 10,000 to 20,000 tons of Lancashire iron and muck bars, but practically no pig iron. Those figures have, however, not been reached after the war.

Insignificant as this export is if you compare it with the enormous consumption of high-grade steel in this country—a couple of years ago it amounted to nearly one million tons a year—it means a great deal to Sweden, especially as we, in our turn, must buy so much from you in the form of foodstuffs, raw materials and machinery. Without selling we would not be able to buy in the long run.

I only wish to add a few words. Some of you gentlemen present here may remember that the British Iron and Steel Institute in 1898 held its Autumn meeting in Stockholm. Quite a number of distinguished American members took the trouble of crossing the ocean to attend that meeting. Among these I especially remember one old friend of ours, who has now, unfortunately, passed away, Fred Daniels of Worcester. No one who had the privilege of meeting him will ever forget him. I am sure

many who are present here were among his personal friends.

I also remember Mr. Hunt—the rail specialist—who made many speeches and always waved his pocket-sized star-spangled banner.

I dare say that none of those who came regretted that they had favored us with a visit.

Now I want to tell you that the Iron and Steel Institute is planning to hold another meeting in Stockholm, and most likely this is going to be in the Autumn of 1925. I take this opportunity to express our sincere hope that, if this plan materializes, a large number of our American friends will also join the meeting. Nothing would give us greater pleasure, and you may be convinced that we will do our utmost to make the meeting pleasant and the excursions, after the meeting, to our steel works and mines, interesting.

On behalf of Jernkontoret, under whose auspices the proposed meeting will be held, I beg to extend to you all a most hearty welcome to Sweden. (Applause.)

JUDGE GARY: We have at this table, I think, the gentlemen who read such very fine papers today. They are entitled to our respect and our gratitude and they have it. I will ask these gentlemen, who are at the table, to please rise. You will recognize them as worthy of our praise and our high regard.

(The gentlemen referred to arose, amid applause.)

Gentlemen, we stand for reciprocity. We seek friends. We desire to be friends. We wish to trade with the countries represented by the distinguished gentlemen who have spoken to us this evening. In all honorable ways up to the full measure of practicability we will cooperate with them in advancing the interests of our countries. Good night.

AMERICAN IRON AND STEEL INSTITUTE

TWENTY-SIXTH GENERAL MEETING

NEW YORK, OCTOBER 24, 1924

The Twenty-sixth General Meeting of the American Iron and Steel Institute was held at the Hotel Commodore, New York City, on Friday, October 24, 1924.

Following the usual custom, three sessions were held. In order to provide sufficient accommodations for the large number present, the morning session was held in the Grand Ballroom. The afternoon session was held in the East Ballroom. The evening session, which included the semi-annual dinner, was held in the Grand Ballroom. The sessions were devoted to the reading and discussion of papers dealing chiefly with problems of metallurgy and business.

On the following page will be found the program of the meeting. Judge Gary, President of the Institute, presided at the opening of the morning session. At the close of his address, Judge Gary requested Mr. Charles M. Schwab, Vice-President of the Institute, to take the chair. At the request of the president, Mr. E. A. S. Clarke, Secretary of the Institute, presided during the afternoon session. Judge Gary acted as toastmaster at the banquet in the evening.

PROGRAM—OCTOBER MEETING

MORNING SESSION

Address of the President.....ELBERT H. GARY
Chairman, United States Steel Corporation, New York.

Blast Furnace Practice in the Birmingham District.....R. H. LEDBETTER
Superintendent of Blast Furnaces, Tennessee Coal, Iron & Railroad Company, Birmingham, Ala.

Discussion.....HOWARD E. MUSSEY
Superintendent of Furnaces, Woodward Iron Company, Woodward, Ala.

The Constitution of Iron Blast Furnace Slags.....RICHARD S. MCCAFFERY
Professor of Metallurgy, University of Wisconsin, Madison, Wis.
And.....JOSEPH F. OESTERLE
Assistant Professor of Metallurgy, University of Wisconsin, Madison, Wis.

Discussion.....B. E. PHENEGER
Assistant General Superintendent, Newburgh Steel Works, American Steel and Wire Company, Cleveland, Ohio.

Discussion.....G. M. HOHL
Superintendent of Blast Furnaces, Bethlehem Plant, Bethlehem Steel Company, Bethlehem, Pa.

The Manufacture of Tinplate in India.....FRANK L. ESTEP
Perin & Marshall, New York.

AFTERNOON SESSION

The Manufacture of Slag Brick and Other Slag Products.....C. E. IRELAND
Vice-President and Sales Manager, Birmingham Slag Company, Birmingham, Ala.

Discussion.....P. J. FREEMAN
Chief Engineer of Tests and Specifications, Department of Public Works, Allegheny County, Pittsburgh, Pa.

Iron and Steel Scrap.....W. VERNON PHILLIPS
Perry-Buxton-Doane Company, Philadelphia, Pa.

Iron and Steel Scrap.....E. J. LOWRY
Metallurgist, Hickman, Williams & Company, Chicago, Ill.

Discussion.....JOSEPH MICHAELS
President, Hyman-Michaels Company, Chicago, Ill.

Discussion.....ALBERT C. MANN
Vice-President, Illinois Central Railroad Company, Chicago, Ill.

Discussion.....W. A. MAXWELL, JR.
General Superintendent, Indiana Harbor Plant, Inland Steel Company, Indiana Harbor, Ind.

EVENING SESSION

Impromptu Remarks in Response to Call of the President.

ADDRESS OF THE PRESIDENT

ELBERT H. GARY

Chairman, United States Steel Corporation, New York

Gentlemen, without any introduction I will announce the subject this morning as Pittsburgh Plus.

On July 21, 1924, the Federal Trade Commission ordered that the respondents, United States Steel Corporation and its subsidiary companies, cease and desist from quoting for sale or selling in the course of interstate commerce their rolled steel products known as plates, bars, structural shapes, sheets, tin plate, wire and wire products at Pittsburgh Plus prices or upon any other basing point than that where the products are manufactured, or from which they are shipped, or without clearly and distinctly indicating in such sales the price charged at shipping point and how much is charged for transportation; and also from discriminating in price between different purchasers within the United States or any territory thereof, or the District of Columbia or any insular possession, where the effect may be to lessen competition in interstate commerce, provided nothing should prevent discrimination on account of difference in grade, quality or quantity, or that makes only due allowance for difference in cost of selling or transportation or that is made in good faith to meet competition.

It is at least doubtful that if the respondents had appealed to the Courts for full and final consideration of all the questions involved, the order of the Federal Trade Commission would have been approved and upheld as coming within the power and authority of the Commission. As to this view you can refer to your

legal departments. Indeed, you probably have already done so.

However, after giving the whole subject careful consideration, the respondents concluded to cheerfully accept and acquiesce in the decision. Many of the leading independents in the steel industry, and perhaps all of them, followed suit.

Many of you were startled by the action of the Commission and temporarily, at least, entertained feelings of disappointment and dissatisfaction. More than that, your business activities and progress have been interrupted, impeded and in places almost demoralized. As yet, you have not been able to restore the natural trend of affairs. Sellers and purchasers alike have been groping for a course that would permit a basis for transactions which would furnish the stability and uniformity which every department of business effort desires and seeks. For the best success in industrial enterprise of any kind it is as necessary to have some standard to reckon from as it is to have a gold dollar basis to make comparison and computation. You are encountering and will continue to encounter difficulties. You may decide to appeal to the courts for remedy; but you are beseeched to give the matter most patient and painstaking thought before doing so.

You have heard that much energy and considerable money has been expended in creating a sentiment that Pittsburgh Plus is wrong in principle; and you have indulged a feeling that the proceedings before the Commission were influenced by personal and selfish motives; but concerning this all of us should endeavor to consider both sides of the case before reaching a final decision.

It will be attempted in this discourse to give a full and strictly accurate account in substance of the facts relating to Pittsburgh Plus.

In the earlier days, because of the proximity of ore and fuel supplies, iron and steel manufacturing and consuming enterprises sprang up in the central coast states,

with Philadelphia as the center. This led to Philadelphia becoming the principal importing point for foreign iron and steel. Therefore Philadelphia was the natural basing point, and purchasers elsewhere bought at Philadelphia prices and paid the cost of transportation to the respective places of consumption. Later the manufacture of iron and steel was begun at Pittsburgh and this rapidly grew in volume. That was then the best location with respect to cost of assembling the raw materials and distributing the finished products. It was adjacent to the steam and coking coal and lime stone, easily and cheaply reached by the iron ore via the Great Lakes and a short railroad from Lake Erie to Pittsburgh, and it rapidly became a great main line railroad center. Consequently, Pittsburgh almost suddenly and naturally became the basing point. For a great many years the cost of producing iron and steel was materially less at Pittsburgh than it was at any other place in the United States. In fact, with equipment in every respect up to the very latest standards, costs at Pittsburgh still are, and will continue to be, with the lowest in the comparative columns. Moreover, the volume of iron and steel produced there still is and will probably remain the largest of any location in the world. If there should be any single basing point for the sale of iron and steel, such as Chicago for wheat or beef and pork, it would naturally be Pittsburgh. Except for changes in conditions and circumstances, arising during the last few years, Pittsburgh unquestionably would still be the basing point for iron and steel. Except for the very system of Pittsburgh Plus, such would be the case. That is, without larger selling prices at Chicago, for instance, than Pittsburgh, furnaces and steel mills would not have been erected in the Chicago district, for investors could not afford to do so. The selling prices necessary to enable capital to secure reasonable returns on investments at Chicago in competition with Pittsburgh were realized by taking as a measure the Pittsburgh prices and adding the amount of freight between the two

cities. This was the only way new locations like Chicago, South Chicago, Gary, Cleveland, Lorain, etc., could influence the establishment of new steel plants in their districts.

But new elements from time to time during the last few years have appeared in the competitive conditions pertaining to the iron and steel industry.

We have seen improvement in practice, such as the lower cost of fuel for the open hearth and blast furnaces by modern coke ovens and the utilization of by-products, the employment of immense sums in creating larger units and the building of breakwater protection and canals in the south shore of Lake Michigan, which permitted the delivery of iron ore from the mines direct to the furnaces, thus matching in part the lesser freights on coal from Kentucky, West Virginia and Pennsylvania to Pittsburgh.

These changes, with others that might be mentioned, together with somewhat larger selling prices, have enabled iron and steel manufacturers at Chicago to successfully compete with Pittsburgh furnaces and mills. As time passed the costs of production at some of the Chicago district works were as low as Pittsburgh, or nearly so, depending upon methods and equipment, and new mills and furnaces at the former were constructed and put into operation.

Subsequently, complaints, increasing in volume, were made that purchasers in certain middle-western localities, were being discriminated against; that it was not just for a Chicago district manufacturer to charge a larger price for steel to be used near or west of the productive plants than the amount charged to Pittsburgh purchasers, arbitrarily adding a sum equal to the freight between the two points when it was not actually paid; that the basis of charging, which was called Pittsburgh Plus, was no longer fair and reasonable.

There is not sufficient time, nor is it necessary, at present, to attempt further explanation concerning the

changes in the general situation which justified the erection of iron and steel works in the Chicago district, and the progress they made. It is sufficient to say up to the period when the United States Steel Corporation was formed, the furnaces and mills at Chicago were not able to successfully compete with the Pittsburgh manufacturers, even with the latter as a basing point for prices so far as it could be used.

Also, in discussing Pittsburgh Plus or Pittsburgh Basing Point, we should not overlook the fact that in actual practice, for several years last past, the system to a greater or less extent has been disregarded by the producers. The competition amongst manufacturers, located in the Chicago district, has been so great on account of their increased and increasing capacity, that they have paid little, and, in a majority of cases, no attention whatever to the question of freight rates from Pittsburgh to western points.

In this connection it is worthy of mention that competition, when it is free and open, uninfluenced by artificial means, always has and always will and ought to fix the selling and purchasing prices of all commodities. Of course, prices will vary to different purchasers, scattered throughout the country, influenced by locations, close to or remote from producing points, capacity and costs of production, necessary charges for transportation, etc. No law or application of legal principles can ever eliminate or change the effect of free and natural competition. It is to protect against artificial or controlled measures or combinations which restrain open and free competition, that laws are provided and enforced. In subscribing and conforming to this principle, the iron and steel industry must and will take a leading part. It is to be hoped and expected that this industry will likewise be afforded protection against combinations or other measures calculated to restrain natural competitive conditions.

In March, 1919, the iron and steel industry of the

United States was reasonably prosperous. The Chicago district had become important. Its productive capacity was large. Its plants were numerous, comparatively new and modern in design. Its costs of manufacture compared favorably with Pittsburgh. Competition amongst the Chicago manufacturers was brisk, and the Pittsburgh Plus system was to some extent in force.

On March 15th, 1919, your President received from the late John S. Miller, then a distinguished and leading lawyer of Chicago, a letter dated March 14th, 1919, stating that he had

> "been retained by the Western Association of Rolled Steel Consumers to take up and look into their complaint of price discrimination on the part of producers of steel against the Rolled Steel Consumers in this territory, such as compose the membership of the Western Association of Rolled Steel Consumers;"

that upon looking into the matter with some care, their complaint seemed to him to be well grounded; that his clients would like to have this discrimination removed without the least bit of friction; and suggested a conference. On March 18th, 1919, your President answered Mr. Miller as follows:

> "I beg to acknowledge receipt of your letter of March 14th instant. I have for some time been carefully considering the subject as an economic one from the standpoint of what is fair and just. As yet, I have not secured an unanimous opinion. However, I do not think it is hopeless."

As many of those who are present here today are aware, this letter stated the facts.

About May 8th, 1919, your President wrote to Mr. Miller:

> "There is no intentional, unnecessary delay on my part. I think we should find a solution for all time. The establishment of a basing point is not generally, if ever, for the benefit of a city or

locality asking for it. Chicago may be independent of these considerations."

Again June 11th, 1919, your President wrote to Mr. Miller as follows:

> "I now expect to arrange for a meeting between your clients and some of the steel people within the next two or three weeks. I am actively considering the matter. There has been no unnecessary delay on my part. The problem is difficult."

It was later decided by representatives of the iron and steel interests to ask their respective lawyers to meet for discussion of the Pittsburgh Plus matters, and they met accordingly. Following their meeting and on June 19th, 1919, your President again wrote to Mr. Miller as follows:

> "On yesterday, I received a letter from the Hon. William C. Redfield, Secretary of Commerce, in which he states he has received complaints concerning the maintenance of Pittsburgh as a basing point, and requesting that several other points be included, such as Buffalo, Cleveland and Chicago, and that he had replied that his department had no jurisdiction of the subject and referred to the Federal Trade Commission as being authorized to act in such cases. As President of the American Iron and Steel Institute I have received several letters on this general subject, some of them of a complaining character. They have been written from Minneapolis and other places. The American Iron and Steel Institute would not be disposed, if it had the right, to represent the steel industry in connection with the discussion pertaining to this matter. I suggest to you that under all the circumstances, it might be appropriate and wise for you and me to visit the Chairman of the Federal Trade Commission, and for you to then state the position of your clients and ask the Commission to make an inquiry into the subject. I would consent so far as our Corporation is concerned. Of course, the whole steel industry ought to be heard in

> regard to such a matter. You may deem it advisable to come to New York and go from here to Washington."

On July 1st, 1919, Mr. Miller telegraphed to your President as follows:

> "I will reach New York Monday morning and communicate with you on arrival. Your suggestion will be acceptable to me. If convenient for you to communicate with Washington about hearing, you may do so on my behalf as well as your own, using my name, and I will be prepared to go from New York to Washington as you suggest."

Your President complied with the request of Mr. Miller and they both appeared before the Commission at Washington July 9th, 1919. There were also present Hon. Victor Murdock, Acting Chairman, Commissioner; Hon. Huston Thompson, Commissioner; Hon. William B. Colver, Commissioner; Dr. Francis Walker, Chief Economist; Mr. Melvin C. Wooster, Chief Accountant. and Mr. Adrien F. Buswick, Chairman, Board of Review. It was agreed by all present that the proceedings should be public.

Mr. Miller then stated his case and your President made a statement. To be thoroughly familiar with all that took place one should read the record, which is public. For the convenience of members of the Institute, there has been printed for distribution an essential part of the record entitled "Exhibit A." This should be considered a part of this address.

It is perhaps sufficient to say that your President acted in behalf of the industry, as requested by the counsel of the larger interests. He said what seemed to him desirable in assisting to secure a decision by the Federal Trade Commission of all the questions pertaining to the Pittsburgh Plus system, on the merits and as affecting every one and any one connected with the business.

It was supposed by your President that the Federal

Trade Commission would include as parties to the proceedings the whole iron and steel industry, and also all others, including various cities and towns, who might be affected by the result. The stand taken by your President with respect to including the entire industry and various localities is definitely and fully shown in "Exhibit A." The Commission did not adhere to this supposed plan and perhaps might be justly criticised for this failure. However, in view of all that had taken place, the Steel Corporation concluded it would not be justified in refusing to acquiesce in the findings and decree which were finally made.

There would have been one of the biggest legal and official inquiries that has ever occupied the courts or governmental bodies if there had been included every interest affected, as was tentatively agreed to, and the whole subject had been referred to and finally adjudicated by the courts. As before suggested, any member desiring to appeal to the courts may still do so.

It is believed the entire iron and steel industry will, within a reasonable time, voluntarily be operating on a basis conformable to the opinion rendered by the Federal Trade Commission, notwithstanding the United States Steel Corporation and its subsidiaries alone were made respondents; and that if we are patient and reasonable we shall find, though with perhaps some additional work and cost, the industry, taken as a whole, and including both producers and consumers, will not materially suffer by reason of the elimination of the Pittsburgh Plus system.

Purchasers generally desire no more and no less than fair and reasonable prices without discrimination, all things being equal. This tends to insure stability in business, avoiding sudden and extreme fluctuations, which is essential to continued prosperity and satisfaction. The ordinary purchaser of any commodity does not desire an unreasonably low price if his neighbor pays the same amount for the same thing at the same place under

the same conditions, and this disposition to be fair should be reciprocated by all sellers, for with this ideal situation the total population in this country has the opportunity to thrive up to the full measure of merit. Unreasonably low prices, especially if they fluctuate, are as bad for every one as unreasonably high prices. Capital and labor alike are interested in these questions. It is up to the iron and steel manufacturers to do their part in both directions.

But for one, your President entertains the opinion that there are involved questions more important than those which are only of a legal nature. What is the fair, the equitable view to take? What is just as between producers and their purchasing acquaintances?

What has been done has caused considerable confusion, some injustice, perhaps some demoralization and unreasonably low returns on investments. But it is to be hoped that all difficulties will readily be overcome and that, in these matters, the entire steel industry will have the patience, the energy and the wisdom to solve the perplexities occasioned by the effort to abrogate the Pittsburgh Plus and before long return to the position of progress and prosperity to which it is entitled.

There is more to excite feelings of doubt and anxiety in our minds, so far as reasonable profits and prosperity are concerned, than the orders of Federal tribunals. Overlooking for the moment political questions and results, reference is made to the disposition of the iron and steel manufacturers themselves. A prominent newspaper editor once said: "There is a good deal of human nature in mankind." Like those engaged in other lines, it is natural for a manufacturer of iron or steel to be selfish and greedy; to seek a temporary advantage even by unfair conduct toward his competitor. He amongst us who is without guilt in this respect, "let him first cast a stone."

If every one of us will persistently deal with all others fairly we shall receive our just deserts. If we

charge only reasonable prices, taking into account the amount of investment, risk of business, vicissitudes of trade, depreciation and upkeep, treat our employes with liberal propriety and acknowledged standards of humanity, conserve the interests of our stockholders or owners, act decently and friendly toward our competitors, carefully consider the demands of public sentiment when we know and understand them, and always obey the laws of the land when they have been made known, then we may expect to prosper and to receive what is our due.

We can afford to submit to a public sentiment, however created or brought about, if and when we are not called upon to sacrifice a moral principle. Then, maintaining this attitude, when such a sacrifice is demanded, we can stubbornly oppose and defend against it, and expect sooner or later to receive commendation and support.

The highest and best rewards come from honest and proper practice. Bad results in the long run come from selfish, unfair and dishonest conduct.

Business Conditions

According to the newspaper reports, based on information gathered from usual sources, confirmed by much additional testimony, there has been a persistent, though somewhat irregular, growth in the volume of business generally throughout the United States since May, 1924. It has been considerably larger each succeeding month. There are no public reports showing the total production and shipment in this country of all classes of steel and iron for this period. However, the subsidiary companies of the corporation which possess something less than one-half the capacity of all manufacturers in the United States, sold about two thousand tons per day more of steel in June than in May, about six thousand more tons per day in July than in June, about ten thousand more tons per day in August than in July, about six thousand tons per day more in September than in August,

and about five thousand tons per day more for the first seventeen days of October than for the first seventeen days of September. The shipments for the same period, on the average, exceeded sales because of the accumulated unfilled orders on the books which were placed prior to May.

Partly due to spirited competition in selling and partly to other causes, including increased costs of production while various works were in less than full operation, and also including the disturbance and confusion created by the abandonment of the Pittsburgh Plus system, so called, the net cash results during the last quarter have been somewhat less in proportion than would be indicated by the tonnage alone. This undoubtedly will be shown by the accounts of the Steel Corporation when they are made up; and unfortunately it is more pronounced as to some of the independent manufacturers. As to the Corporation, it is believed the profits for the last quarter were substantial notwithstanding the adverse influences adverted to.

The future success of the iron and steel industry in this country is assured if the managers will keep their heads, and further if the approaching election results shall be satisfactory. As to the first proviso, we have the opportunity and the responsibility. As to the second, it is for the majority of the national electors to determine whether or not they desire continued prosperity. All of us, all the people of the United States, must together enjoy prosperity or suffer from adversity.

It goes without saying that business conditions in this country during the next year and during the next four years depend largely upon the result of the election on November fourth proximo. Every well-informed business man or woman knows that if the best men are elected there probably will be continued and increasing prosperity, and that if others less capable and less worthy are selected we may expect depression and disturbances in business, less production, more idleness, less comfort,

more distress; a decided interruption to legitimate progress that will not be easily nor soon overcome.

In this greatest of all nations, with largest opportunities for worthy achievement and human happiness, there is possibility of suicidal action or neglect that will cause immeasurable loss and suffering to multitudes.

But sentiments of self-protection will influence the large majority of voters to give careful thought to the best interests of the country and themselves, and they will therefore wisely discriminate and decide. In this most important, if not critical, period in our history, they can be depended upon to act along the lines of prudence and safety. They will not take unnecessary chances of danger by adopting untried and uncertain theories or by selecting officials whose competency is assured largely, if not alone, by their own professions and promises.

No name for president is mentioned in these remarks; no political creed will be discussed; but some of the qualifications for the official leader of our great and beloved country may properly be referred to. First of all, he should be possessed of the highest moral principles. He should be absolutely impartial, disposed to favor no person or aggregation or interest to the undue prejudice of another. He should be modest, plain and simple, and still courageous, dignified and wise. He should ascertain the facts and patiently consider before he decides any question presented. He should truthfully and frankly inform the country concerning all public matters whenever it can be done without prejudice to governmental interests, relying upon an honest people for approval concerning the merit of his attitude. He should not hesitate to speak the truth, when it is necessary, nor to remain silent when no one could be injured thereby. He should be willing to lend his influence and devote his talents to legitimate business, progress and general prosperity, and likewise to prevent and penalize corruption and wrong. He should endeavor to assist and to protect the poor, the weak and the suffering, and, at the same

time should be willing to help the rich, the strong and the happy when it is indisputably right to do so. He should practice and enforce strictest economy and husband all resources in governmental administration, but should not indulge in false economy. He should be willing to properly cooperate with and to assist foreign nations, entertaining always an intention of first considering and protecting the interests of his own country.

Notwithstanding, as usual, every fourth year we are passing through a mud-slinging campaign, with its unfavorable effects, except there is an extraordinary quantity of mud this year, we shall find that an intelligent and fair-minded majority will be wise and courageous in their action. An overruling Providence, up to the limit of what this country deserves, will guide and direct the people. We will succeed in all laudable undertakings in spite of the unworthy efforts and words of unprincipled or incompetent individuals.

Our Ship of State is too great, too fine, too solid, substantial and strong to be pronounced unseaworthy on the words of unscrupulous, unintelligent or inexperienced men, and then turned over to a board of underwriters. I am convinced the public has been right during the last few months in believing the election returns will be satisfactory, as shown by the steady and persistent increases in the volume of business. With such a result we may look forward through the autumn and succeeding months with hope and confidence. We shall not make ourselves a laughing stock to the onlookers of foreign countries, some of whom possibly watch and comment upon our attitude. We shall be friendly to them and, so far as proper and practicable, will be helpful, but we shall keep ourselves in the moral, financial, commercial and industrial condition necessary for the best service and most active assistance whenever justly called upon.

Gentlemen, are any of you pessimists? Are you discouraged or down-hearted? Look ahead. Our lands, our

climate, our wealth, our productive and transportation facilities, our increasing consuming desire and capacity, our educational advantages, our churches, our protective national constitution, our floating flag, our spirit of loyalty, all remain. Demagogues or anarchists or fakers cannot deprive us of these blessings. Where else on earth can be found another such a nation? Let us be thankful, hopeful, confident and determined. Let us be loyal to our country, to all others who are interested in what we do or say, and to each other.

(After long continued applause).

Gentlemen, will you allow me to thank you. To speak to such an audience, to an audience of such men as you, to talk to men of intelligence, education and experience, who know the difference between right and wrong regardless of what unprincipled people may say, and above everything else men with hearts big enough to transact business in which all are interested in such a way that they give evidence they intend to show fairness and honesty and friendliness; and above all else men with hearts big enough to endure and be patient with such a man as I, you may be sure excites the feelings of deepest friendship and hearty gratitude. Thank you.

EXHIBIT "A"

Excerpts from Proceedings Before the Federal Trade Commission

A conference with representatives of Western Association of Rolled Steel Consumers and United States Steel Corporation, in regard to Pittsburgh Basing Point Practice, Washington, D. C., July 9, 1919.

Judge Gary: The whole iron and steel industry ought to be in here. You ought to have jurisdiction over the whole thing. It is one of the most important questions that you have ever had before you, or ever will have before you, if you take jurisdiction, as I think you ought and as I think you can. I believe it is a matter to

be settled by this Commission. That is my judgment about it.

Perhaps I need not pursue further the statement of conditions, but I want to say that it seems to me there must be a different application of principles to different companies that are engaged in the manufacture of iron and steel. Some of them have mills in the East and in the Middle West both, like the United States Steel Corporation. The Republic Iron & Steel has mills situated in different places, I think; I know they are interested in Birmingham, as well as Youngstown and some other places—to some extent in Pittsburgh, I think. Now, different locations are more or less competing, because they want their territories built up. Different manufacturers in these locations are more or less competing, because some have mills at Pittsburgh and mills at Chicago and that vicinity, Cleveland, and so forth, and could supply from different districts. Others have only plants located at Pittsburgh, and would be more or less cut off from other territories; and then, when you commence to do that, will the general consumer suffer or profit, part of the competition having been removed? It is a proposition to change the methods of doing business, to disarrange the plans which have been in force, and therefore every community is entitled to be heard, I think, and certainly every producer of steel and every different class of consumer. It would be ideal, for instance, for Mr. Wagner if he could have this basing proposition changed so as to make Pittsburgh and Chicago the basing points and the only basing points.

Mr. Miller: He would be satisfied with that. He has no objection to a base mill; he has a mill in Milwaukee. But he would be satisfied, as all the members of this association would be satisfied, with a provision Pittsburgh-Chicago.

Judge Gary: That would be totally unsatisfactory to Duluth, you will see.

Commissioner Colver: Birmingham would soon be

along, and it would not be satisfactory to Birmingham. I suppose Pueblo would be heard from.

JUDGE GARY: Yes; quite likely.

COMMISSIONER MURDOCK: Of course "the tail goes with the hide."

JUDGE GARY: Yes. Now then, I just want to state my position, representing now the Steel Corporation only.

COMMISSIONER THOMPSON: Judge, you said you thought we ought to take jurisdiction.

JUDGE GARY: I do. I think you ought to take jurisdiction.

COMMISSIONER THOMPSON: Upon what grounds do you think we have jurisdiction?

JUDGE GARY: On the ground that the consumers are complaining that there is discrimination on the part of the manufacturers of steel in regard to selling prices. This is not my point, but they complain of that.

MR. MILLER: It is our point.

JUDGE GARY: Yes; it is their point. They make that point, and they are entitled to have it heard, it seems to me. Now, I am not trying to bring work to this Commission, because Lord knows you have enough; but I am disposed to say that from my standpoint I would like to have this question fully heard on the evidence, so that the facts from the beginning to the present can be determined, and then every interest heard that desires to be heard, and then the whole question settled, so that the Steel Corporation at least could say to anybody hereafter complaining, "There is an adjudication of this question, and we are following the judgment and decree of the Federal Trade Commission." If it is right to have this changed, I would like to have it done. I will say, speaking for our Corporation, that the matter of making a little more or a little less money on account of this basing price does not appeal to me at all.

Now then, the Steel Corporation might be in better position to assume that attitude than some other steel manufacturers; so those manufacturers ought to be

heard. I do not want to do anything, and I do not want to be a party to anything that would prejudice our competitors, any more than I do our consumers. It is a responsibility that I do not want to assume. I want them to have a chance to be heard.

COMMISSIONER MURDOCK: Judge Gary, the question is a pretty big one, and not only involves this proposition, but involves the whole economic structure of society.

JUDGE GARY: It does.

COMMISSIONER MURDOCK: And you mentioned one point that, if you will, I wish you would dilate upon a little bit, and that is the advantage to the community at large in stability in a commodity and its price.

JUDGE GARY: In the first place, stability in business of any kind is the first essential.

COMMISSIONER MURDOCK: Is that not only from the viewpoint of the industry itself, but from the viewpoint of the consumer?

JUDGE GARY: Yes.

COMMISSIONER COLVER: And the public interest?

JUDGE GARY: Yes; and the public interest. I am firmly of that opinion. Every man doing business, whether he is a purchaser or a seller, whether he is a fabricator or buys to sell again, is better prepared to do business and is more successful in business if he has some foundation which he thinks will not change from day to day or from month to month, and which is not fluctuating, which is not susceptible to fluctuation. If you were going to build a block on a lot which you have in Washington today, and the market in regard to steel and brick and other commodities was changing rapidly and frequently, you would begin to make calculations as to what Mr. Colver could do if he decides to wait and build next year. For instance, if the points of delivery change, the methods of delivery change, the methods of handling change, and are susceptible to influences which go beyond the mere law of supply and demand, then the man desiring to use

the commodity in question is not protected unless there is some stability of fundamental agencies.

In regard to different communities, if a man is solicited to locate a mill, a plant of any kind, at a certain city or a certain point in the country, of course he begins to figure what will be the results of that business conducted from that point. Now, if he finds upon inquiry that unless he is in some way protected by some basing arrangement which will allow him to enter into competition with the man who has a mill at Pittsburgh or Chicago or some other place; if he finds he would labor at such a disadvantage that he could not survive there, he will not do that. Consequently the community will say, "That ought to be changed; he ought to be permitted to manufacture in our location, within reasonable limits, at a price which will enable him to compete with Pittsburgh and these other points;" and therefore, if it is decided that everything is to be sold f.o.b. mill, the community that is desirous of making extensions and improvements, enlarging its city, is disadvantaged and prevented from succeeding.

It is difficult to commence a discussion of these questions without going into various things that I do not want to go into now, Mr. Chairman, because, in the first place, I do not want to say anything that should in the least prejudice Mr. Miller's case, and more especially I do not want to say anything that could possibly prejudice any of our competitors in business, or any community—like Duluth and West Superior, if you please—or the general public. If this Commission can be satisfied now that Mr. Miller has made a complaint—and he has made it; he has been after me for about three months, and he may have thought I was a little slow; his clients undoubtedly did; but I have tried to talk this question first with my associates in business, and then with some of the other steel people as I would casually meet them, and not until finally I said to them that Mr. Miller was going to press this claim before the Federal

Trade Commission, and it had to be determined on the merits, did I receive much encouragement from the other steel men that they were willing to recognize that anybody had any claim or any right. And they are entitled to be heard. Mr. Miller's clients are entitled to be heard; other steel purchasers are entitled to be heard. We often have consumers, members of our Institute, come to our office and say, "For mercy's sake don't reduce your prices." And I say, "Don't you want to buy cheaper?" "No, I don't want to buy cheaper now. I want those prices maintained if you can do it, because in the first place I have got an inventory on hand, and I don't want the price of that inventory reduced; in the next place, I am making my contracts now with other people, and if you disarrange that, then I have got to change my prices with them, and so forth; and I am in the midst of putting up a building and I don't want demoralization."

COMMISSIONER COLVER: That brings you back to your statement about stability.

JUDGE GARY: Stability; it comes back to that. Now, assume that you take jurisdiction; and for one I would like to have you take jurisdiction if you can, I do not know that I have got a competitor in business who would agree to that; probably not; but I would like to have you take jurisdiction if you can, because I want it settled. And if you do take jurisdiction, I would like to have you appoint your member, or in any way you please, take such evidence as is necessary, and get all the facts, and then I would like to have you hear from everybody on the subject, and then settle this question of basing point once for all, and settle it right.

Now, I admit that that is about as big a lawsuit as ever came before any judicial tribunal. I admit that. But it is important, and I believe you have got the jurisdiction, and I think some one ought to settle it; because these complaints in regard to basing point are growing in numbers and in severity, and it is not a comfortable place.

Now, Mr. Miller, excuse me.

MR. MILLER: That is all right.

I do not think the Commission need be appalled by the magnitude of the question here. I do not know how much it will broaden out. It came about in this way: The people that I represent had enjoyed the double basing for a while—

COMMISSIONER MURDOCK: By the way, Mr. Miller, Mr. Wagner is located in Chicago, is he?

MR. MILLER: Milwaukee. He is president of the Wisconsin Bridge & Iron Company. We have members in Minneapolis, and so on around the Middle West. These people are from the Middle West, in what is called the Chicago district, extending as far west as the Missouri River or farther. I think all west of Pittsburgh to the coast would share in the desire for at least the double basing, Pittsburgh and Chicago.

The reason I approached Judge Gary about this is very obvious. He is president of the American Iron and Steel Institute, and he is the executive head of the great United States Steel Corporation. That corporation has a plant at Gary in the Chicago district, and one at Pittsburgh in the Pittsburgh district. It was selling its steel, as we conceive, discriminating between customers. Its customers in the Chicago district, buying their steel from the Gary mill, were paying an exaggerated price, a price that was higher than the customers of their Carnegie mill at Pittsburgh were paying. That seemed to me to afford an instance of discrimination in price as to which the Commission has jurisdiction. It seemed to be, too, a case of unfair competition within the powers of the Commission.

With the growth of our country this Middle West district is chasing the Pittsburgh district in development. It happens, as Judge Gary says, that at one period of time, when the steel industry was young—I think one of my clients remarked, through the foresight of a little Scotchman who has interested himself in the steel busi-

ness in that region—Pittsburgh became the great iron and steel producing center. They had the ore and they had the coal close by. Since then the greatest ore-producing district in the world, perhaps, is in Minnesota, near the head of the Great Lakes; and, being wise, Judge Gary's great corporation started a very large plant at Gary, at the head of Lake Michigan. They could bring their ore from the Minnesota ore beds by their huge steamers down to Gary, and it happens that Gary taps a very large coal supply; and my clients tell me that in this speech that Judge Gary spoke about, at Duluth—I think he stated it today—it was stated that the production of steel at Gary is even lower in cost at present than the production of steel at Pittsburgh, and I think Judge Gary concedes that at least they are on an even keel. The Gary plant is a huge plant, and the Inland plant is a large plant, near Gary; it is an independent company. The Interstate is a considerable one.

Now, if I had not gotten into the contact with Judge Gary that I did, and if instead of taking it up in that way, as I conceived to be wise and called for, I had come first here, I would have come with a concrete complaint against his company for violation both of the Clayton Act and of the Federal Trade Commission Act. I agree with Judge Gary that this question is broad and involves large interests. I do not mean merely the interests of the steel producers; it is larger than that—

COMMISSIONER MURDOCK: Oh, yes, much.

MR. MILLER (Continuing): Or even these fabricators in the Middle West, who are very, very large; but every consumer of steel in the Midwest and between the Pittsburgh district and the Pacific coast is interested in the question of whether there goes into the price of the steel that he puts into his building or his structure or his use—agricultural implements or whatever it may be—a swollen price of $5.40 a ton that does not represent any element of cost; the idea being that a fair price for a product is cost plus a fair profit. Here you have an

artificial element. So far as these consumers in the Middle West are concerned, you have got an artificial element by which the price to them is not fixed on cost, or cost plus a fair profit, but is fixed artificially in order to harmonize prices.

Now, the matter of stability of price, to which the Commissioner referred, of course has its great value.

COMMISSIONER MURDOCK: I would like to hear you on that, Mr. Miller, because the whole tendency of present-day society is in the direction of stability in industry, and it is an element that enters in, and it enters in in apparent contradiction of the good old theory of competition. I would like to hear you on that proposition.

MR. MILLER: I am no economist; I am a lawyer.

JUDGE GARY: He is extravagant.

MR. MILLER: Judge Gary was a great lawyer, and then became a very great economist, and I am still plodding along in a modest way and practicing law.

JUDGE GARY: But on the top rung.

MR. MILLER: I would say about that, speaking with a very great deal of diffidence, that you have not yet solved that question entirely, with a country like ours, where ten years produces an industrial revolution—produces a growth, perhaps, that never was dreamed of. Judge Gary's development of his town out there, that took his name, would never have been dreamed of ten or twenty-five years before it started. The trouble with stability is that you are dealing with an unstable situation, with the growth of your country. Stability is desirable, but it is only within very small limits, or reasonable limits, in my opinion, that you can get it; because with the growth of your country you produce new centers and new conditions that upset your theories of a few years before. Stability is an ideal rather than a practical conception, in my opinion, or any approach to it. We are all the time working to it within certain limits. As to competition, I think it is still the life of trade; and I suppose the Sherman Act still has vitality, and perhaps teeth—I know it

did have a good many teeth at one time—and I think competition, too, is called for.

COMMISSIONER MURDOCK: Mr. Miller, you said that this involved, in this commodity, all stages, all elements that touch the commodity—the consumer and the fabricator and the steel mill. A decision by this Commission on this question, in my opinion, will involve not only steel but many other commodities which follow this general line, and I would like to get this idea to you and see if you can clear it up in my mind. Pittsburgh, being the original producer of steel and the center of steel, gathered to itself not only the steel mills, but fabricators and steel industries of many kinds, and all the integrated parts of the steel were turned into things for society at Pittsburgh. So Pittsburgh did become the center of this proposition.

MR. MILLER: It had all the ore. It had everything at its door.

At the close of his address Judge Gary requested Mr. Charles M. Schwab, Vice-President of the Institute, to take the chair.

THE CHAIRMAN (Mr. Charles M. Schwab): Judge Gary has asked me to relieve him of presiding during the reading of the papers to follow his address. I am sure there is not a man here who has not appreciated the splendid address which our distinguished chairman has given us this morning. I believe it is the best that we have ever had the pleasure of hearing from him. He seems to improve with each succeeding year (applause). I know, Judge Gary, that I voice the feeling of every man here, when I say that this Institute owes you a great debt of gratitude for your wonderful leadership of this great industry. (Applause).

We will now have a paper on Blast Furnace Practice in the Birmingham District by R. H. Ledbetter, Tennessee Coal, Iron and Railroad Company, Birmingham, Ala.

BLAST FURNACE PRACTICE IN THE BIRMINGHAM DISTRICT

R. H. Ledbetter

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The Birmingham District, as usually defined, includes the territory furnishing raw materials to the iron and steel industries of Birmingham and vicinity, an area about sixty miles long and thirty miles wide. The striking economic feature of this district is the location of the iron ore deposits and coking coals on opposite sides of the valley, approximately six miles apart, with outcroppings of a very good dolomite, which fulfills all requirements for a fluxing stone.

The iron ores used in the furnaces of the district consist largely of hard red hematites, with a small percentage of soft red hematites and brown hematites or limonites.

The "red ore," as it is commonly called, is a bedded deposit of fossiliferous red hematite which occurs in the Clinton formation. The Clinton formation of the Red Mountain district includes about two hundred feet of strata, mainly sandstones and shales, with several beds of iron ore, only two of which are of commercial importance, the Big Seam and the Irondale Seam. The Big Seam supplies most of the tonnage of the district and on the outcrop on Red Mountain shows workable thickness over an extent of about sixteen miles.

The Big Seam at the north end, opposite Birmingham, is about thirty feet thick and gradually thins to the southwest to about six feet at Potter, two miles below

Bessemer. At the Ishkooda Mines of the Tennessee Coal, Iron & Railroad Company, the ore shows about seven per cent acid. At the Wenonah Mines, in the center of the field, the ore is about self-fluxing, and at Muscoda, further south, the ore shows five to six per cent excess base.

The ore close to the outcrop, in which the lime has been more or less leached out, is known as "soft ore." The workable soft ore is almost exhausted, and today very little is being supplied to the blast furnaces.

The following are typical analyses of Big Seam ore, which, as stated, constitutes the principal supply for all the furnaces:

	Ishkooda	Wenonah	Muscoda
Moisture	1.00	1.00	1.00
Iron (Fe)	36.82	37.10	35.28
Silica (SiO_2)	17.90	13.18	10.38
Alumina (Al_2O_3)	3.03	3.05	3.12
Lime (CaO)	13.67	16.02	19.35
Manganese (Mn)	.17	.16	.16
Phosphorus (P)	.37	.36	.30

To the northeast of Birmingham, a limited tonnage of ore is being mined from the Irondale Seam. A typical analysis of this ore shows: iron 33.67, silica 22.54, alumina 5.00, lime 12.89.

The ore is mined by slopes driven directly into the ore seam, in which case the ore is hoisted in two-ton ore cars, or, as later developed by the Tennessee Coal, Iron & Railroad Company, slopes are now sunk ten feet below the workable ore seam and equipped with steel skips of twelve tons capacity. About seventy per cent of the ore is mined, thirty per cent being left to support the overlying measures. The ore is hoisted to the surface and dumped into pockets, from which it is fed by gravity into gyratory crushers and crushed to two to two and one-half inches, discharging into standard gauge railroad cars. The distance from mines to blast furnaces varies from four to eighteen miles.

Brown ore or limonite in limited quantity is used by a few furnaces. It is desired by most all furnacemen, but

its increasing cost and irregular supply makes it prohibitive.

The brown ore occurs in massive and fragmentary form, and is generally associated with overlying limestone. The main source of supply is from the Woodstock locality, about thirty miles southwest of Birmingham. It is here mined by three of the district's iron producers, viz: The Woodward Iron Company, the Tennessee Coal, Iron & Railroad Company and the Republic Iron & Steel Company. The overburden of sand and clay is removed by stripping. The intermixed clay and ore are loaded by steam shovels into cars, which deliver to washers. The ordinary log washer is used for separating the ore and clay. There is considerable variation in the iron and silica content of most of the brown ores, the iron showing from thirty-eight to fifty-two per cent and silica from eleven to thirty per cent.

The coking coals of the Birmingham District are limited to the Warrior Field, which lies on the northwest side of the district. The principal coal seams of this field are the Pratt and Mary Lee, or Big Seam, which occurs five to six hundred feet below the former. The Pratt Seam furnishes approximately seventy per cent of the total coking coal used in coking operations of the district. This seam is mined by slopes from the outcrop and shafts in the flat lying coal west of the outcrop. The seam varies from three to six feet in thickness. The Big Seam averages from five to seven feet as mined, but contains more partings than the Pratt Seam and is higher in ash. To produce a good blast furnace coke of desirable ash content, it is necessary to wash practically all the coals. A representative washed Pratt coal will show about the following analysis: volatile matter 30.80, fixed carbon 63.90, ash 5.30, sulphur 1.25.

The stone mainly used for flux in the manufacture of pig iron in the Birmingham District is the dolomite which outcrops extensively in the valley. The stone, as it occurs, is a very pure dolomite, carbonate of calcium and

magnesium, requiring no preparation other than crushing and screening. At two of the blast furnace plants it is quarried not exceeding one mile from the stockhouse charging bins. While limestone is plentiful in the district, dolomite is preferred by most furnace operators, particularly when making basic iron. With the lower hearth temperatures necessary to produce basic and low silicon iron, the slags are thinner and more easily handled when they contain from four to six per cent magnesium oxide than when the base is all calcium.

Twelve years ago fully ninety per cent of all blast furnace coke produced in the district was made in the beehive oven. Since that time the regenerative by-product oven has replaced the wasteful beehive. Three by-product coke plants are today operated by iron producers, and a fourth is coking coal for a three-furnace plant, which has recently abandoned its beehive ovens. The Tennessee Coal, Iron & Railroad Company's coke plant at Fairfield, three miles from the Ensley Group of furnaces, consists of four hundred and thirty-four ovens of the Koppers type, with a daily carbonizing capacity of seven thousand tons of coal, yielding about five thousand tons of metallurgical coke. The Woodward Iron Company has two hundred and thirty ovens of similar design, and the Sloss-Sheffield Steel & Iron Company has one hundred and twenty Semet-Solvay ovens, with a daily capacity of approximately twenty-four hundred tons of coke.

There are in the district twenty-four operative blast furnaces, with a total annual capacity of 2,735,000 gross tons of iron.

The Tennessee Coal, Iron & Railroad Company has six modern skip-filled and six hand-filled furnaces of a combined annual capacity of 1,500,000 tons of basic and foundry irons. The Republic Iron & Steel Company, operating exclusively on merchant iron, has three furnaces, the total rated capacity of which is 325,000 tons. Sloss-Sheffield Steel & Iron Company, with two hand-

filled and two skip-filled furnaces, has a capacity of 350,000 tons. The Woodard Iron Company has five furnaces, four modern mechanically-filled and one small hand-filled, with a total rating of 550,000 tons of basic and foundry grades.

The furnaces of the district vary in size from the smallest of approximately 10,000 cubic feet in content to the largest of 31,235 cubic feet, the latter being the cubical content of the recently rebuilt No. 1 Ensley stack of the Tennessee Coal, Iron & Railroad Company.

There is nothing unusual about the construction of any of the southern blast furnaces. On account of the low metallic content of the ore charge, they produce more than 2,300 pounds of slag for each gross ton of iron. This excessively high slag volume is very destructive to hearth linings, and as a result frequent iron and cinder breakouts have occurred, a number of which have been serious. However, in recent years this has been largely overcome by stronger jackets, better protected and cooled. At a number of the furnaces, particularly those of the Tennessee Coal, Iron & Railroad Company, the hearth well has been done away with. The jackets are made of cast steel segments four to five inches thick, with cast iron cooling plates on the inside extending the full depth of the hearth jackets. A number of the furnaces are constructed with cast iron hearth jacket, the segments usually being linked together. When cooling is necessary, this type is usually sprayed.

The tuyere zone is protected with cast iron or steel segments completely covering this area. On account of the cutting action of the slag, no furnaces in this district are constructed with exposed brick in this section. It is often necessary to maintain a constant spray of water to prevent overheating.

There are two types of bosh construction followed: one is the usual block bosh, consisting of from four to eight rows of copper cooling plates inserted into cast iron housings, the other of one to three rows of copper plates

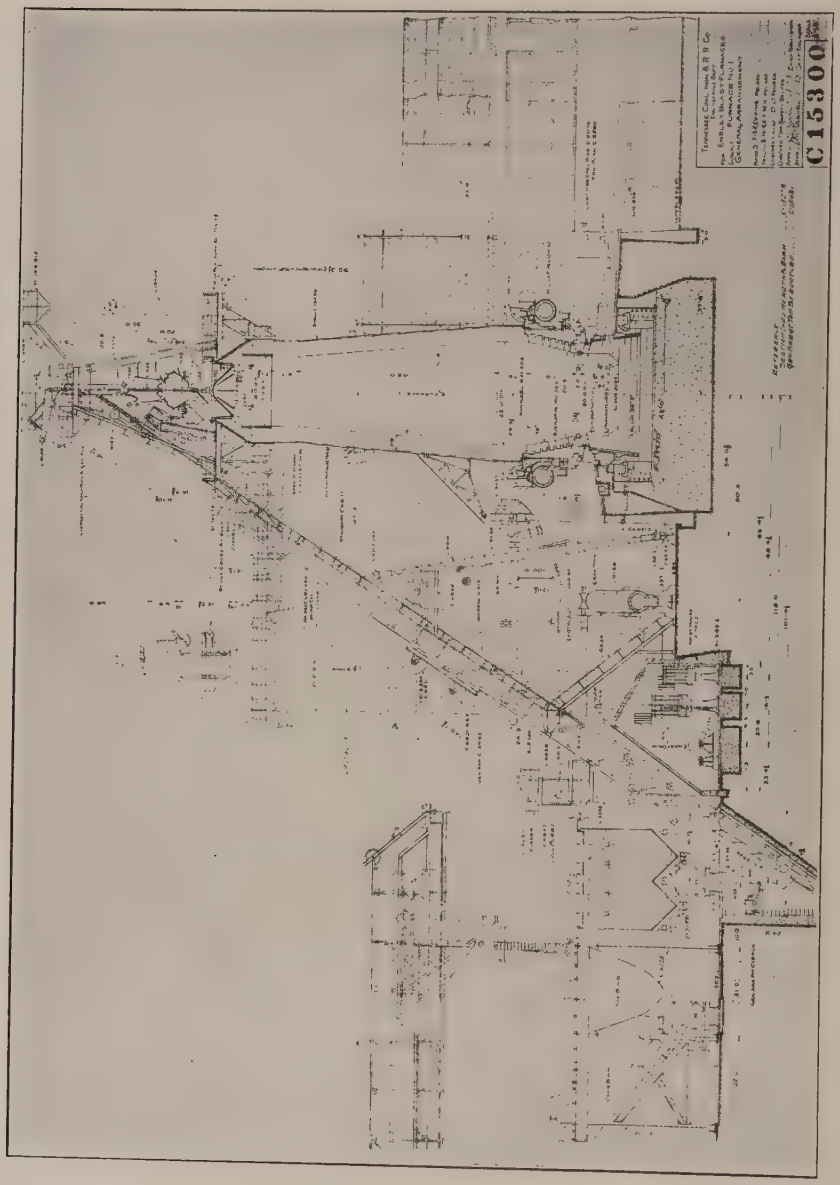

Fig. 1—No. 1 Furnace, Ensley, Tennessee Coal, Iron & Railroad Company.

immediately above the tuyere jackets, the remaining portion of the bosh being housed with steel plate one-half to one inch thick, which is either cooled with a series of water sprays or by cast iron inside cooling plates extending to the furnace mantle. With one or two exceptions, the larger furnaces have adopted the former type. The "petticoat jacket," as this steel protection is called, proves very satisfactory for the smaller furnaces.

The mantles are constructed of either heavy reinforced cast iron sections, or fabricated I beams or channels, or both. The furnace shells are of the usual construction.

There are no so-called "thin-lined" furnaces in the district. No. 1 Furnace of the Ensley Group, Tennessee Coal, Iron & Railroad Company, was rebuilt in 1911 as a thin-lined stack, but was, however, dismantled in 1921 and replaced by the present furnace now in operation. A number of furnaces have one or more rows of copper cooling plates above the mantle. This construction, however, is not general.

On account of the excessive abrasive action of the southern furnace charge, attributable largely to the refractory hard red ores, the top brick soon suffer unless protected. A number of types of stock line protectors are in service. The one generally used, and probably best adapted to local conditions, consists of a heavy cylindrical cast iron ring, three inches thick of a height of seven feet, reinforced with three-quarter-inch plate on the outside. They are either supported by brackets fastened to the shell or rods from the tunnel ring or top cone.

Nine of the twenty-four furnaces are hand-filled, and are provided only with a single large bell without gas seal. The size of the bell varies with the diameter at the stock line, the usual practice being to make the bell of about four feet smaller diameter than the furnace at the stock line. The angle of this bell is usually forty-five degrees. The cubical capacity of the receiving hoppers

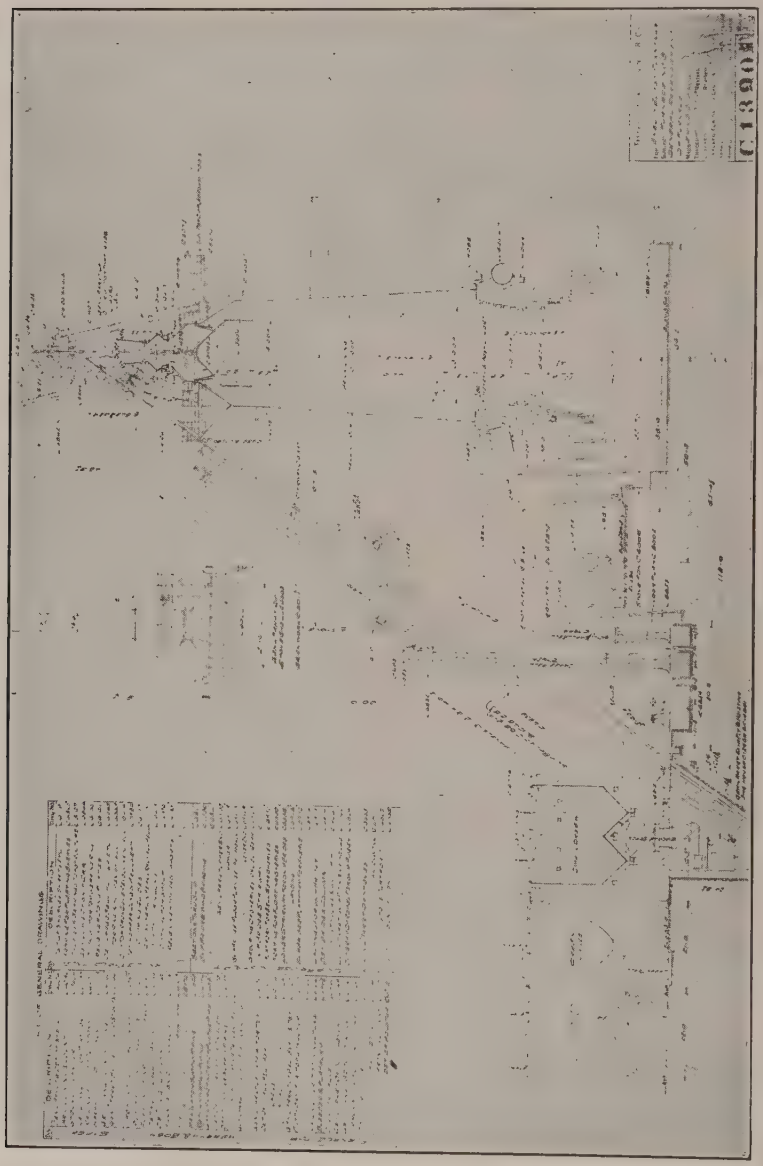

Fig. 2—No. 3 Furnace, Ensley, Tennessee Coal, Iron & Railroad Company.

are designed to hold one complete charge of from sixteen to twenty-two thousand pounds of ore, coke and stone.

Of the fifteen mechanically-filled furnaces, thirteen are equipped either with the Brown or McKee type top modified to suit local conditions. The top constructed by the Tennessee Coal, Iron & Railroad Company and in use on all of its six skip-filled furnaces has given excellent results. Nos. 2 and 3 Ensley Furnaces have each produced more than one million tons of iron on a lining. No. 2 Ensley Furnace, now in blast, has produced on its present campaign 960,000 tons, and promises to cross the million ton mark before the first of the coming year. No. 3 Ensley, at present in blast and in good condition, has made more than three-quarters of a million tons on its lining. This top consists of a stationary receiving hopper, to a revolving section of which is attached a distributor spout, this section being driven by a crank from the shaft of a sheave wheel carrying skip cables. It is equipped with a small bell of a diameter of 4′9¼″ immediately above the revolving section, this bell acting as a gas seal and closing only when the large bell is lowered. The diameter of the large bells on five of the six furnaces is twelve feet, that of the No. 1 Furnace being thirteen feet. The distributor can be adjusted for any degree of travel by changing the stroke of the driving mechanism. It is at present adjusted for a travel of sixty-four degrees for each trip of the skip car from pit to top. Six skips constitute a coke unit. This gives an overlap of twenty-four degrees for a complete charge of fuel, and since ten skips constitute a complete charge, it requires ninety trips or nine full charges to bring the distributor to its original starting point. Both bells are operated by the skip hoist tender, the large bell cylinders being operated by water and the small ones by steam.

Many types of stoves are in use, the two-pass, the three-pass and the four-pass all being in service. The majority of the older hand-filled furnaces are equipped with the four-pass stove of the Whitwell type. The

twelve stoves of the Republic Iron & Steel Company at Thomas are three-pass central combustion chamber of the Massick & Crooke design. Twenty of the twenty-seven stoves of the Ensley Group, Tennessee Coal, Iron & Railroad Company, are three-pass central combustion chamber designed by McClure. The remaining seven are two-pass, four of which are central combustion chamber, and three, side combustion chamber. Of the twenty-seven stoves at Ensley, the smallest, a 20′x85′ two-pass central combustion chamber stove, has a heating surface of approximately 46,000 sq. ft., and the largest, a 25′x110′ two-pass side combustion chamber stove with six-inch checkers, has a total heating surface of 90,000 sq. ft. The blast temperatures maintained in this district are probably higher than in other iron producing districts of the country. At the different plants, it ranges from 1100° to 1400°. The records covering a period of more than a year show an average blast temperature of 1170° for the Group of Ensley stacks operating on low silicon iron.

No gas blowing engines are used in the district. Twenty-one of the twenty-four furnaces are blown with reciprocating engines, principally of the vertical long cross-head type. Three furnaces of the Ensley Group are supplied with blast from two turbo blowers operating on exhaust steam from reciprocating engines, and one blower driven by high pressure steam, superheated. Barometric condensers are used with the low pressure blowers, while the exhaust from turbine using superheated steam is condensed by a surface condenser and the condensate discharged into heater and used for boiler feed water.

The steam for prime movers is generated almost exclusively by vertical water-tube boilers, the fuel for which is supplied by blast furnace gas, supplemented by hand firing of coal and at some plants by the use of by-product coke oven gas. At the Ensley boiler plant, the largest in the district, there are six 834 H. P. boilers

equipped for using blast furnace gas or pulverized coal, as desired.

The principal sources of water supply for the blast furnaces of the district are Village and Valley Creeks, the former furnishing the two Vanderbilt stacks of the Woodward Company, the Sloss North Birmingham furnaces, the Republic furnaces at Thomas and Tennessee Coal, Iron & Railroad Company's Ensley and Fairfield Works. To maintain an adequate supply, the Tennessee Company has an impounding dam about seven miles below Ensley. There is located at Edgewater, nearby, a pumping station equipped with two turbines of 30,000,000 gallons capacity each and two vertical reciprocating pumps of 12,000,000 gallons capacity each, giving a total of 84,000,000 gallons per twenty-four hours. From this point, the water is pumped to a high level reservoir of 17,500,000 gallons capacity and distributed to its Ensley Furnaces, Steel Works, Fairfield Coke Plant and Steel Works. Valley Creek supplies Woodward and the Tennessee Company's Bessemer Furnaces Nos. 3 and 4, Nos. 1 and 2 Bessemer Furnaces deriving most of their water from nearby mining operations of the Sloss and Republic Companies. With the exception of the water for Oxmoor Furnace, which is obtained from Shades Creek, all of the furnace supply is very hard and shows as high as eighteen grains per gallon of carbonates and sulphates of calcium and magnesium. When untreated, this, of course, adds considerable expense to boiler maintenance on account of frequent reaming and scaling of hard precipitates. On account of the limited supply of water, it is necessary to circulate almost all water used for cooling and condensing.

In recent years more attention has been paid to the cleaning of blast furnace gas. The demand for higher blast temperatures, greater wind volumes and finer crushing of ores have resulted in dirtier gas. In addition to the original dust catchers, a number of the furnaces have gone further into the cleaning of their gas,

particularly that portion which is used in the stoves. At Thomas, the Republic Company have, in addition to the primary dust catcher, a Mullen washer for each furnace and an individual washer of the Stewart design for each stove, from which they get very good results. At Ensley Furnaces no wet cleaning has been applied. Nos. 1 and 2 Furnaces are provided with one vertical primary and one horizontal secondary dust catcher. No. 3 Furnace has one vertical primary and one horizontal secondary, and a six-unit Kling-Weidlein dry cleaner. No. 4 Furnace has the vertical primary and a two-unit whirler of the Brassert type. Nos. 5 and 6 Furnaces, in addition to vertical primary dust catchers, are each equipped with a two-unit whirler of Brassert design.

The flue dust production of the furnaces of the district will average approximately 135 pounds per ton of iron. A month's average analysis of the dust produced by the Ensley Group of furnaces shows: iron 26.02, silica 12.21, alumina 2.94, lime 12.16, carbon 23.59. The low metallic iron and high carbon content of the dust prohibits sintering by any of the present known commercial systems. There is, however, one sintering plant operating in the State, at which plant a mixture of flue dust and iron pyrites is sintered. The dust from the dust catchers and the dry cleaners is usually carted away or loaded in railroad cars and wasted with plant refuse. Where washers are used, it is usually removed from the settling basins by a locomotive crane and disposed of in the same manner.

Fifteen of the twenty-four furnaces normally produce iron for the market, all of which is cast in sand beds. A large percentage of this tonnage is disposed of to nearby plants and used in the production of high pressure water pipe, sanitary pipe and fittings, stoves and miscellaneous castings. Eight of the nine remaining furnaces produce basic or low silicon iron, which is handled as hot metal directly to steel works for conversion into open-hearth steel. One furnace is usually operated on ferro-

manganese, low phosphorus or special iron to fulfill the needs of the steel works.

There are no known ores in the Birmingham District available in commercial quantities for the manufacture of bessemer pig iron. The average phosphorus content of the red hematites, which constitute ninety per cent of the iron ore supply, shows three-tenths of one per cent, and since it requires approximately two and seven-tenths tons of ore for one ton of pig iron, the resultant phosphorus content in the iron is about eight-tenths of one per cent. For many years, bessemer and low phosphorus iron were purchased from other districts for the manufacture of ingot molds and special castings. A few years since a method was developed for the manufacture of low phosphorus iron without the use of iron ore. This is done by charging into the furnace steel scrap, coke, gravel, dolomite and a small quantity of manganese ore. The steel scrap of the charge consists mainly of rail ends and bloom crops, with a small percentage of miscellaneous plate and rod scrap. The following is a typical furnace charge when operating on this iron: steel, 12600 pounds. coke 5700, dolomite 4600, river gravel 1800. The gravel is added to furnish the acid to permit the use of additional dolomite to increase the slag volume for the absorption of sulphur in the coke. A very high grade bessemer iron is produced, which cannot be distinguished from that produced from iron ore. On a recent campaign of No. 2 Bessemer Furnace of the Tennessee Company 12,000 tons were produced, which showed an average analysis of: silicon 1.95, sulphur .028, phosphorus .076 manganese .82. Total carbon content will average about 4.25 per cent. The quantity of slag produced per ton of iron, of course, can be governed. After experimenting, it has been found that with ordinary steel scrap of about .04 sulphur and coke 1.10 sulphur, 800 pounds of slag per ton should be made. This keeps the sulphur well below the saturation point of the slags and permits the control of the sulphur in the iron. An average slag analysis for

BLAST FURNACE RECORD OF NO. 3 FURNACE, ENSLEY WORKS, TENNESSEE COAL, IRON & RAILROAD COMPANY, AUGUST, 1924

Date	Total Tons Iron Produced	Coke Consumed Per Ton Iron (Pounds)	Stone Consumed Per Ton Iron (Pounds)	Ore Mixtures (Per Cent.)		Blast			Top Gas Temperature	Atmospheric Moisture Grains Per Cu. Ft.
				Hard Red Ore	Converter Slag	Cu. Ft. Per Minute	Temperature	Pressure		
1	513	2,441	463	94.0	6.0	52,800	1,100	14.5	450	9.06
2	478	2,699	532	94.0	6.0	55,680	1,200	16.4	510	8.91
3	447	2,575	560	94.0	6.0	53,760	1,210	16.2	480	8.69
4	471	2,551	542	93.0	7.0	55,040	1,110	17.2	485	9.19
5	485	2,634	521	93.0	7.0	56,640	1,100	15.6	450	8.93
6	525	2,508	536	93.0	7.0	56,640	1,170	16.6	470	8.85
7	463	2,760	555	93.0	7.0	56,000	1,160	16.9	480	9.05
8	448	2,682	564	93.0	7.0	56,000	1,180	17.2	450	8.82
9	271	2,384	481	93.0	7.0	28,800	1,180	17.2	420	8.73
10	526	2,300	552	93.0	7.0	52,800	1,180	14.8	460	8.47
11	503	2,565	659	93.0	7.0	56,000	1,180	16.4	480	9.02
12	486	2,707	685	93.0	7.0	56,640	1,160	16.2	490	8.49
13	579	2,381	491	93.0	7.0	56,320	1,180	17.2	445	6.82
14	533	2,492	487	93.0	7.0	56,640	1,130	16.7	490	7.00
15	546	2,409	481	93.0	7.0	56,000	1,120	16.2	480	6.67
16	465	2,809	534	93.3	6.7	56,000	1,160	15.2	430	7.94
17	561	2,368	509	95.0	5.0	56,640	1,150	16.4	500	8.77
18	478	2,620	600	95.0	5.0	56,960	1,130	16.0	480	8.65
19	522	2,496	582	95.0	5.0	56,960	1,150	17.1	470	8.45
20	513	2,638	590	95.0	5.0	56,000	1,100	16.7	450	8.38
21	471	2,901	570	95.0	5.0	54,400	1,160	16.4	480	8.05
22	456	2,774	588	95.0	5.0	56,000	1,180	15.4	485	8.13
23	554	2,330	486	95.0	5.0	56,960	1,110	14.7	490	7.93
24	452	2,743	635	95.0	5.0	53,760	1,100	14.8	510	8.08
25	432	2,811	709	95.0	5.0	54,400	1,100	15.2	510	7.54
26	478	2,699	686	95.5	4.5	56,960	1,110	15.3	540	7.21
27	565	2,306	585	95.5	4.5	56,960	1,120	14.8	530	7.07
28	491	2,530	676	95.5	4.5	56,960	1,115	14.8	515	7.72
29	458	2,790	587	95.5	4.5	54,400	1,110	15.7	515	7.77
30	544	2,442	532	95.5	4.5	56,320	1,120	15.3	545	7.98
31	481	2,735	509	95.5	4.5	56,320	1,100	15.8	525	7.73
Totals and Averages.....	15,195	2,581	565	94.2	5.8	55,180	1,144	16.0	485	8.20

Totals and Averages for Month	
Grade of iron	Basic
Total tons produced	15,195
Average daily tonnage	490.16

Analysis of Production:

Silicon	Sulphur	Phos.	Mang.
.98	.056	.81	.54

Analysis of Slag:

Silica	Alumina	Sulphur	
37.28	10.73	1.15	

Pounds Material Consumed Per Ton Iron for Month	
Ore, Cinder, Scale and Scrap	6,081
Coke	2,581
Stone	565
Total	9,227

Averages for Month	
Cu. ft. air per minute	55,180
Cu. ft. air per pound coke	60.5
Blast temperature	1,144
Blast pressure	16.0
Top gas temperature	485
Moisture (grs. per cu. ft.)	8.20

this campaign shows: iron oxide (FeO) .71, silica (SiO_2) 37.07, alumina (Al_2O_3) 7.07, lime (CaO) 35.47, magnesia (MgO) 17.82, sulphur (S) 1.39. The gas from the furnace when operating on this product shows about ten B. T. U. higher than ordinary blast furnace gas, but considerably lower in sensible heat, averaging four per cent. The iron is cast in ordinary sand beds, from which it is removed and broken in the usual way. No trouble is experienced in breaking so long as sulphur is maintained under .05 and silicon above 1.50 per cent, since this retains most of the carbon in the graphitic state. High sulphur and low silicon produce an iron high in combined carbon, which is malleable and, of course, very difficult to break. From 900 to 1200 pounds of coke are required to produce a ton of this iron. This operation should not be confused with that of the cupola. Besides melting the scrap and slag forming constituents, it returns to the metal all that was removed in the converter and the open-hearth except the phosphorus.

No. 1 Furnace at Ensley, the largest in the south, with a cubical capacity of 31,235 cu. ft., consumed in August, just past, 71,712 gross tons of raw material, yielding 17,602 tons of iron, with a coke consumption of 2515 pounds per ton of product. During this month the furnace was blown by turbo blower, delivering an average of 60,830 cu. ft. of air per minute, with an average blast pressure of nineteen pounds.

No. 3 Furnace of the Ensley Group, typical of the larger furnaces in the district, is of the following dimensions: hearth 18′6″, bosh 23′0″, bosh height 12′9″, bosh angle 80°, stock line 16′0″, total cubical contents 25,435 cu. ft. This stack is equipped with five three-pass central combustion chamber stoves of 51,000 sq. ft. heating surface each, or a total heating surface of 255,000 sq. ft. It is being supplied with air by five vertical reciprocating blowing engines. For the month of August, the average daily blast requirement for this furnace was 55,180 cu. ft. per minute, with average blast pressure of

sixteen pounds. The average blast temperature maintained was 1144°, with an average top gas temperature of 485°. A total of 62,594 gross tons of coke, ore, stone, cinder, scale and scrap was consumed in this furnace during the month. The gross metallic yield of mixture was 37.92 per cent. On account of this low yield, 9227 pounds of coke, ore, stone, cinder, scale and scrap were required to produce one ton of iron. Coke consumed per ton of product for the month was 2581 pounds. Of the total ore consumed, ninety-four per cent was hard red hematite, the remaining six per cent being converter slag, which was added to maintain the percentage of manganese desired in the iron. The furnace produced a total of 15,195 tons of iron for the month, with an average daily tonnage of 490.16 tons.

At present, with the exception of one Ensley stack, all the furnaces waste their slag on fills adjacent to the furnace plants. Slag is transported to these fills in cinder ladle cars of capacity varying from 150 to 395 cu. ft., some hand dumps, but the majority operated by steam. Slag is removed from these fills by either steam or electric shovels, a portion of which is crushed, sized and cleaned and disposed of for concrete aggregate, the remainder being used for railway ballast, etc. A portion of the fines produced from the crushing plant at Ensley is used, with the addition of Portland cement, for the manufacture of building brick.

The Chairman (Mr. Charles M. Schwab): The paper will be discussed by Mr. H. E. Mussey, Superintendent of Furnaces, Woodward Iron Company, Woodward, Ala.

Discussion by Mr. H. E. Mussey,

Superintendent of Furnaces, Woodward Iron Company, Woodward, Ala.

The excellence of Mr. Ledbetter's paper leaves very little ground for discussion on blast furnace practice in

the Birmingham District. However, I will talk for a few moments on its development since the earlier days.

Furnacing depends very largely on three things, namely: the construction of the furnace plant; the quality and preparation of the raw materials; and the general operation of the furnace, commonly referred to as the furnace practice.

We will first take up the furnace construction, using No. 1 Furnace of the Ensley plant of the Tennessee Coal, Iron and Railroad Company in 1888 and the same furnace in 1924 as comparisons. The comparative dimensions of the furnace are as follows:

Furnace No. 1	1888	1924
Height of stack, feet	80	96
Hearth diameter, feet	11	20⅓
Bosh diameter, feet	20	25
Height of bosh, feet	26	12½
Bosh angle, degrees	80	78
Capacity, cubic feet	15,295	31,235
Stock line diameter, feet	15¼	17

The principal difference, aside from the cubical content of the furnaces is in the height of the bosh. The furnace of 1888 having an extremely high bosh. This probably was due to the use of a very large percentage of brown ore. As the brown ore became exhausted it became necessary to substitute hard ore, and it was found that this high bosh did not adapt itself to the new condition, the furnace being inclined to build up on the bosh and make heavy slips and blow-throughs. Another difference is in the comparative size of the hearths, the tendency of the present day being to construct much larger hearths than in the earlier days. These two changes along with the development of an efficient mechanical top are probably the three most important features in the furnace construction.

The following is a brief description of the top on No. 2 Furnace at our Woodward plant developed by Mr. Crockard, which I consider to be as good as any mechanical top that I know of: "The Woodward furnaces are single-skip furnaces, whereas those of the Tennessee

company are double-skip. For this reason, the Woodward tops, while representing a simplified form of construction over the original Ensley tops, must provide movable deflecting plates over the upper bell, to minimize segregation, which is not strongly in evidence with the double-skip top. These baffle plates, on either side of the central bell rod, split the charge on the principle of the well-known sample riffle. Between skips, each baffle is automatically rotated 90 degrees, and a half skip load is then directed to alternate quarters of the furnace, thus avoiding the possibility of any section receiving an excess of fines. The rotation of the baffles is effected by small steam cylinders, which are interlocked with the little bell cylinder, making the operation automatic. The mechanism has proved very satisfactory and requires no other attention than the periodic replacement of the wearing plates. The spout of the distributor moves through 64 degrees per skip trip."

Mr. Ledbetter, in his paper, fully covers the character of the ore being used at the present time. I would like, however, to put particular stress on the benefit to be derived from the crushing of the ore. In the early days the ore, which came from the mines in large lumps, was broken by hand in the stock houses into man-size ore. A great deal of trouble was encountered in carrying burden and in the general working of the furnace due to the use of large ore. For that reason crushers were put in at practically all of the mines and it has been our experience that the finer the ore is crushed the more burden we can carry and we get a very much better working furnace. At the present time the general standard for ore is that the greatest dimension shall not exceed two inches. I would not be at all surprised to see our ore concentrated at some future date.

Prior to about 1911, practically all of the coke used in the district was from beehive coke ovens. This coke was very much larger and much more open in structure than the by-product coke used at the present time, and

TABLE A.—BLAST FURNACE RECORD—NO. 1 WOODWARD FURNACE, OCTOBER 1-19, 1924

Date	Total Tons Iron Produced	Coke Consumed Per Ton Iron (Pounds)	Stone Consumed Per Ton Iron (Pounds)	Hard Ore (Per Cent)	Blast			Top Gas Temperature	Atmospheric Moisture Grains Per Cu. Ft.
					Cu. Ft. Per Minute	Temperature	Pressure		
1	453	2,849	0	100	74,309	1,395	21.7	400	4.1
2	482	2,911	0	100	77,578	1,330	22.3	460	6.4
3	526	2,629	38	100	71,267	1,385	21.5	410	7.4
4	422	2,914	92	100	71,219	1,375	21.0	450	9.5
5	489	2,660	82	100	71,080	1,350	20.5	395	8.4
6	425	2,989	22	100	71,528	1,375	20.0	425	8.1
7	492	2,520	0	100	72,082	1,405	20.5	420	7.8
8	440	2,809	0	100	71,415	1,360	21.3	430	8.6
9	512	2,515	0	100	73,868	1,340	22.3	450	7.8
10	393	3,302	0	100	73,830	1,400	21.7	460	7.6
11	407	3,012	0	100	72,269	1,400	22.0	455	6.9
12	467	2,801	0	100	73,530	1,380	21.7	410	7.4
13	510	2,706	0	100	73,680	1,370	23.2	450	6.7
14	547	2,542	0	100	75,349	1,375	23.7	440	6.9
15	482	2,799	0	100	75,233	1,330	21.7	520	7.1
16	480	2,554	0	100	75,350	1,260	21.0	525	7.6
17	516	2,555	0	100	75,680	1,310	22.0	500	7.1
18	481	2,698	0	100	74,238	1,315	22.3	525	7.8
19	560	2,446	39	100	75,570	1,325	22.3	515	6.9
Averages.....	478.1	2,731	14	100	73,636	1,357	21.7	455	7.4

Totals and Averages for Month, Estimated from First 19 Days' Operation	
Grade of iron	Foundry
Total tons produced	14,821
Average daily tonnage	478.1

Analysis of Production:

Silicon	Sulphur	Phos.	Mang.
2.03	.033	....	.24

Analysis of Slag:

Silica	Alumina	Sulphur	
36.67	11.93		

Pounds Material Consumed Per Ton of Iron for Month, Estimated from 19 Days' Operation	
Ore	6,265
Coke	2,731
Stone	14
Total	9,010

Other Averages for Month, Estimated from First 19 Days' Operation	
Cu. ft. air per minute	73,636
Cu. ft. air per pound coke	75.6
Blast Temperature	1,357
Blast Pressure	21.7
Top Heat	455
Moisture (grs. per cu. ft.)	7.4

this difference in coke was responsible to a great extent for several changes in furnace practice.

Due to the fact that we have to reduce 2.75 tons of ore to make one ton of pig iron, it is necessary that we drive our furnaces much faster than the Northern furnaces are driven in order to get anything like a satisfactory tonnage. The result is that the tendency in the South for several years has been to blow more and more wind. Our furnaces show a willingness to take all the stove heat available with this increased wind, so we have not increased the wind at a sacrifice of coke consumption. With a low wind volume and high stove heats our furnaces show a tendency to become sluggish and work on high pressure, but by increasing the wind to the proper amount our pressure is reduced and the movement of the furnace becomes regular. I am inclined to believe that the limit for wind has been reached only on account of not having more stove heat to back it up.

Table A states the furnace practice for the first nineteen days of the present month of our No. 1 Furnace at Woodward, which is on foundry iron. Comparison with the data given by Mr. Ledbetter shows the differences in practice between foundry and basic grades. The cubical content of No. 3 Ensley Furnace is 25,435 cubic feet and No. 1 Woodward Furnace is 21,627 cubic feet.

In closing I wish to emphasize the statement made by Mr. Ledbetter that further improvements in this district are to be made by the better preparation of stock and by increasing the stove capacity.

THE CHAIRMAN: (Mr. Charles M. Schwab). The next paper will be The Constitution of Iron Blast Furnace Slags, by Professor Richard S. McCaffery, Professor of Metallurgy, University of Wisconsin, Madison, Wis.

THE CONSTITUTION OF IRON BLAST FURNACE SLAGS

Richard S. McCaffery
Professor of Metallurgy, University of Wisconsin, Madison, Wis. and
Joseph F. Oesterle
Assistant Professor of Metallurgy, University of Wisconsin, Madison, Wis.

The Metallurgical Laboratory of the University of Wisconsin has for some time past carried on research work to determine the physical properties of blast furnace slags. To simplify the problem in the beginning we considered only those slags composed of silica, alumina and lime; but when the work was extended to include slags containing magnesia, as well as the above three constituents, we realized that we would have to make models to represent the slag composed of four constituents, as it was no longer possible to represent satisfactorily a four component system by means of a drawing in a plane and all blast furnace slags contain some magnesia.

Although blast furnace slags are composed ultimately of the four constituents—silica, alumina, lime, and magnesia, they are actually composed of compounds of these substances, some of the compounds containing two, some three and some four of these ultimate constituents. In all, there are eighteen compounds of silica, alumina, lime, and magnesia that enter into the composition of slags, in addition to the ultimate constituents themselves, or twenty-two in all, so that actually any slag may contain one, two, three, or four of these compounds or ultimate constituents. Table A is a list of these twenty-two components.

The problem then is to determine how these twenty-two different components go into solution, one in the other, and what effect varying amounts of these components have on the physical and chemical properties of the slag.

TABLE A.—LIST OF THE COMPONENTS OF SLAG

1.	Cristobalite	SiO_2
2.	Calcium bisilicate	CaO, SiO_2
3.	Anorthite	$CaO, Al_2O_3, 2SiO_2$
4.	Clino-enstatite	MgO, SiO_2
5.	Diopside	$CaO, MgO, 2SiO_2$
6.	Cordierite	$2MgO, 2Al_2O_3, 5SiO_2$
7.	Sillimanite	Al_2O_3, SiO_2
8.	Spinel	MgO, Al_2O_3
9.	Corundum	Al_2O_3
10.	Gehlenite	$2CaO, Al_2O_3, SiO_2$
11.	Madisonite (new)	$2CaO, 2MgO, Al_2O_3, 3SiO_2$ (?)
12.	Forsterite	$2MgO, SiO_2$
13.	Akermanite	$2CaO, MgO, 2SiO_2$
14.	Monticellite	CaO, MgO, SiO_2
15.	Periclase	MgO
16.	Calcium orthosilicate	$2CaO, SiO_2$
17.	Tricalcium disilicate	$3CaO, 2SiO_2$
18.	Tricalcium aluminate	$3CaO, Al_2O_3$
19.	Pentacalcium trialuminate	$5CaO, 3Al_2O_3$
20.	Calcium aluminate	CaO, Al_2O_3
21.	Tricalcium pentaluminate	$3CaO, 5Al_2O_3$
22.	Lime	CaO

Of the many possible types of solution, it happens that these twenty-two components form among themselves, solutions of only two types. One, and by far the commonest type in slags, is like the solution formed by metallic lead and tin, with a eutectic at some intermediate composition, and the other type is like the solution of gold and silver which forms an isomorphous series. In the silica, alumina, lime, magnesia system, there are only two isomorphous series, the diopside—clino-enstatite or pyroxene series, and the akermanite—gehlenite or melilite series. All the others are of the eutectic forming type.

The system of four components, the sum of which is 100%, cannot be represented by drawings on a plane, so that it was necessary to construct space models. The situation was somewhat simplified by the fact that all the binary systems in the four component systems CaO, MgO, Al_2O_3, SiO_2, formed either simply eutectic mixtures or isomorphous solutions. It is possible to use the equilateral tetrahedron to represent a four component system, for in such a solid, if perpendiculars are drawn from any point within to the four sides, the sum of these perpendiculars will be a constant.

Using then the equilateral tetrahedron to represent the four component system CaO, MgO, Al_2O_3, SiO_2, the faces were constructed from the equilibria of the three component systems involved, and the interior of the tetrahedron was divided into tetrahedra of four component systems, the ternary eutectics were located on the faces of these interior tetrahedra and the quarternary eutectics were located inside each tetrahedron. The complete model shows the spaces of composition of primary crystallization and from the location of the interior tetrahedra faces the approximate mineral composition of a slag of any composition can be determined.

Figs. 1, 2, 3, and 4 show the four faces of the CaO, MgO, Al_2O_3, SiO_2 tetrahedron, and Fig. 5 is a drawing to show the structure of the model.

A great many interesting things were brought out by a study of the CaO, MgO, Al_2O_3, SiO_2 model. For example, the authorities say that in considering blast furnace slags, the chemical equivalent in CaO, of the MgO present may be added to the CaO present. This is totally and completely wrong, for any slag which contains MgO has as a part of its composition some of the magnesia minerals present, such as pyroxene, forsterite, akermanite, spinel or cordierite. The physical properties of these magnesia minerals are quite different from the non-magnesia minerals in slags, say calcium bisilicate, anorthite, gehlenite, calcium monosilicate or calcium sesquisilicate and it is immediately recognized that the addition of the chemical equivalent of the MgO to the CaO is incorrect.

There is another point clearly brought out by a study of the CaO, MgO, Al_2O_3, SiO_2 model. There are certain slag compositions which if used in the blast furnace give operating results that vary greatly if there is a comparatively small change in the ultimate composition of the slags. The reason for this is that any slag is composed of four and only four components or mineral entities and the physical properties of these components determine the physical properties of the slag. These slags are

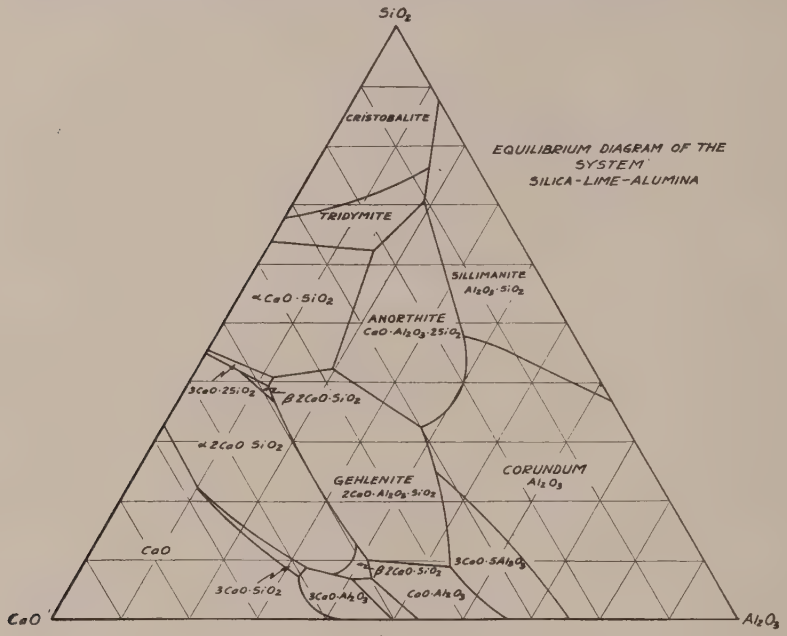
SiO2
CRISTOBALITE
EQUILIBRIUM DIAGRAM OF THE SYSTEM SILICA-LIME-ALUMINA
TRIDYMITE
SILLIMANITE Al2O3·SiO2
α CaO·SiO2
ANORTHITE CaO·Al2O3·2SiO2
3CaO·2SiO2
β 2CaO·SiO2
α 2CaO SiO2
GEHLENITE 2CaO·Al2O3·SiO2
CORUNDUM Al2O3
CaO
3CaO·5Al2O3
β 2CaO·SiO2
3CaO·SiO2
3CaO·Al2O3
CaO·Al2O3
CaO
Al2O3

Fig. 1.

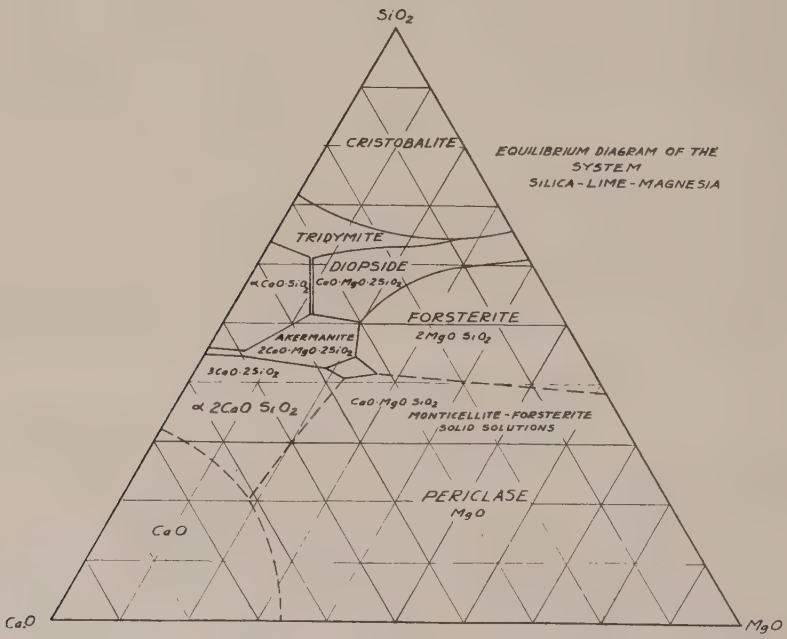
SiO2
CRISTOBALITE
EQUILIBRIUM DIAGRAM OF THE SYSTEM SILICA-LIME-MAGNESIA
TRIDYMITE
DIOPSIDE CaO·MgO·2SiO2
α CaO·SiO2
FORSTERITE 2MgO SiO2
AKERMANITE 2CaO·MgO·2SiO2
3CaO·2SiO2
α 2CaO SiO2
CaO·MgO SiO2
MONTICELLITE-FORSTERITE SOLID SOLUTIONS
PERICLASE MgO
CaO
CaO
MgO

Fig. 2.

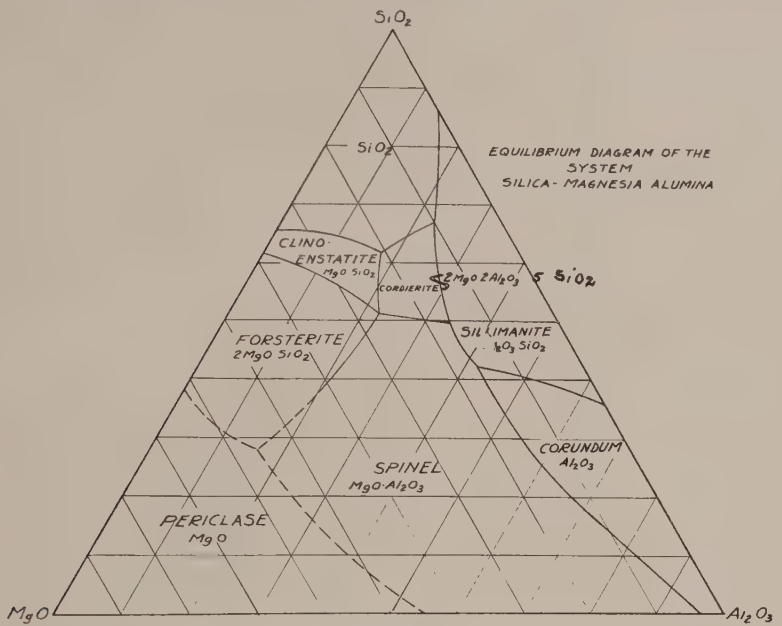
SiO2
SiO2
EQUILIBRIUM DIAGRAM OF THE
SYSTEM
SILICA - MAGNESIA ALUMINA
CLINO-
ENSTATITE
MgO SiO2
CORDIERITE
2MgO 2Al2O3 5 SiO2
FORSTERITE
2MgO SiO2
SILLIMANITE
Al2O3 SiO2
SPINEL
MgO·Al2O3
CORUNDUM
Al2O3
PERICLASE
MgO
MgO
Al2O3

Fig. 3.

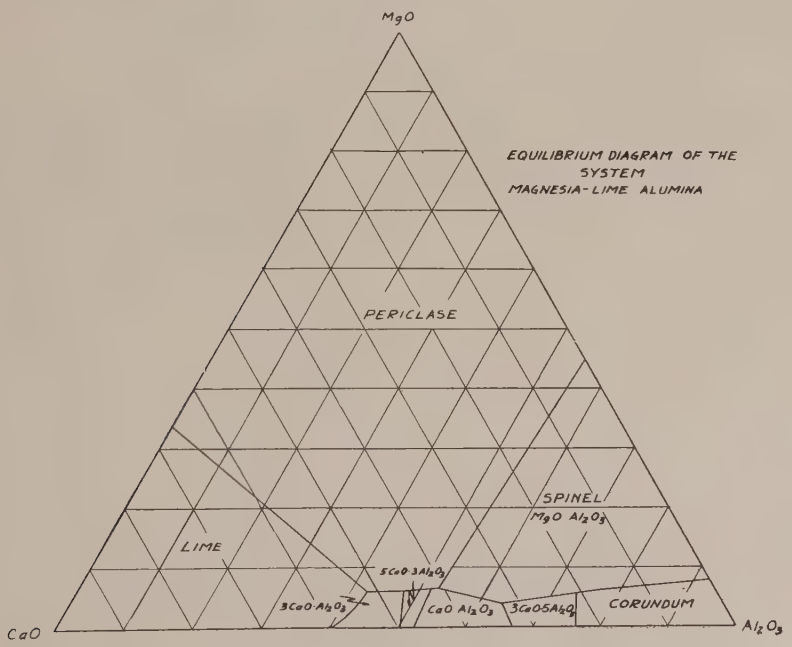
MgO
EQUILIBRIUM DIAGRAM OF THE
SYSTEM
MAGNESIA - LIME ALUMINA
PERICLASE
SPINEL
MgO Al2O3
LIME
5CaO·3Al2O3
3CaO·Al2O3
CaO Al2O3
3CaO5Al2O3
CORUNDUM
CaO
Al2O3

Fig. 4.

Fig. 5—Drawing showing model of the four component system, silica, alumina, lime, magnesia.

of such composition that a slight variation in the percentage of one or more constituents present, will change greatly the blast furnace operating results on slags, the composition of which is on or very near the boundary plane of the smaller internal tetrahedra. Being on or near this plane, a very small ultimate composition change would vary considerably the mineral composition of the slag and of course in so doing would vary its properties. This matter of critical slag composition has been checked over with some blast furnace superintendents, who agree in placing these critical ranges of composition where the space model indicates they are located.

To investigate the location of typical slags in the space model, another model on a larger scale was constructed taking in that part of the larger system that included the composition of all blast furnace slags and in this model were plotted a large number of American, English, French, German and Swedish blast furnace slags that were chosen to show the greatest possible variation in composition.

The data concerning these slags are shown in Table B and the analyses are plotted in Figs. 6 to 10 which represent sections of the tetrahedron on planes that are five per cent magnesia apart. On to these planes are projected the analyses, two and a half per cent each side of the plane. For example, on Fig. 7 which represents the 5% magnesia plane, analyses from 2½% MgO to 7½% MgO are projected.

The slags so illustrated range themselves roughly into three groups; the silica, calcium bisilicate anorthite pyroxene type of charcoal furnace slag, the bisilicate anorthite gehlenite mellitite type of coke furnace slag and the gehlenite, anorthite akermanite montecellite type of coke furnace slag. These three types, although they slightly overlap, show decided groupings into the one charcoal furnace type and the two coke furnace types. The reason why the practical furnace man avoids the two regions of composition where spinel and forsterite are

TABLE B—ANALYSES OF TYPICAL BLAST FURNACE SLAGS

No.	Type	Place	Slag Analyses as Reported								Recalculated so That $SiO_2+Al_2O_3+CaO=100$		
			SiO_2	Al_2O_3	CaO	MgO	MnO	FeO	Alk.	CaS	SiO_2	Al_2O_3	CaO
1	Basic	Oberschlesien	37.35	8.19	35.85	13.06	4.00	1.31	.....	1.25[3]	45.89	10.06	44.04
2	Basic	Gebr. Stumm, Neunkirchen	30.24	18.05	42.40	3.96	2.67[1]	1.05[2]	.....	0.78[3]	33.34	19.90	46.75
3	Basic	Vulkan, Duisberg	31.92	9.83	46.73	2.03	3.78	0.71	.....	4.36	36.07	11.11	52 81
4	Basic	Röchlingsche	30.09	17.96	43.44	0.46	1.52[1]	0.96[2]	.....	2.40[3]	32.88	19.63	47.48
5	White Iron for Puddling	Donnersmarck	34.47	5.67	33.04	20.56	3.40[1]	1.34[2]	.....	2.82[3]	47.10	7.75	45.14
6	White Iron for Puddling	Vares	31.57	5.10	42.10	2.07	6.81	1.01	.....	5.96	40.08	6.47	53.44
7	White Iron for Puddling	Krombach in Mahren	38.72	17.32	26.30	14.01	2.19	.....	.....	1.30	47.02	21.03	31.94
8	White Iron for Puddling	Bogschan	48.80	8.88	26.50	4.11	9.02	2.26	.....	0.20	57.97	10.54	31.48
9	Grey Iron	Osnabrück	29.20	7.14	39.40	18.30	.....	1.60	.....	4.50	38.55	9.43	52.02
10	Grey Iron	Schwechat bei Wein	33.25	12.17	31.26	12.94	4.91	0.95	.....	1.98	43.36	15.87	40.76
11	Grey Iron	Kopparberg, Sweden	47.56	5.48	32.26	8.65	5.06	0.38	.....	1.08	55.75	6.42	37.82
12	Grey Iron	Donnersmarck	24.93	32.21	37.38	0.46	0.40[1]	1.15[2]	.....	4.16[3]	26.37	34.07	39.54
13	Grey Iron	Donnersmarck	35.54	23.21	29.21	3.97	0.32[1]	1.54[2]	1.42[4]	4.12[3]	40.40	26.38	33.21
14	Bessemer	Bochumer Verein	29.31	9.13	46.79	10.85	0.14[1]	0.59[2]	.....	2.99[3]	34.38	10.71	54.90
15	Bessemer	Königin Marienhütte	30.20	9.22	39.23	12.31	1.13	.....	.....	4.79	38.40	11.72	49.87
16	Grey Iron	Hörde	29.45	12.83	39.78	8.10	1.95	0.54	.....	8.20	35.88	15.63	48.47
17	Grey Iron	Witkowitz in Mahren	30.94	9.70	46.08	4.49	2.47	1.60	3.36[4]	2.68[3]	35.67	11.18	53.13
18	Grey Iron	Luxemburg	37.38	10.94	46.14	1.99	0.72	1.00	.....	.....	39.57	11.58	48.84
19	Grey Iron	Steelton, Pa., Spanish Ore	33.68	11.93	45.96	6.69	.....	.....	.....	.....	36.78	13.02	50.19
20	Grey Iron	Steelton, Pa., Cuban Ore	32.27	14.57	41.02	10.30	.....	.....	.....	.....	36.75	16.59	46.71
21	Grey Iron	Steelton, Pa., Cuban Ore	34.26	11.53	40.25	13.28	.....	.....	.....	.....	39.83	13.41	46.80
22	Grey Iron	Steelton, Pa., Lake Ore	35.84	14.34	32.71	17.46	.....	.....	.....	.....	43.23	17.30	39.46
23	Grey Iron	Steelton, Pa., Lake Ore	35.11	14.21	28.41	22.38	.....	.....	.....	.....	45.17	18.28	36.54
24	Basic	.....	35.97	11.34	44.34	2.90	0.66	0.43	0.25[5]	3.93	39.24	12.37	48.37
25	Foundry	.....	35.89	15.25	37.90	4.50	0.58	1.09	0.44[5]	3.20	40.30	17.12	42.56
26	Average in U. S.	.....	35.32	13.07	40.17	5.51	2.06[6]	.....	.....	3.87	39.88	14.75	45.35
27	.....	Cuban Ore	25.70	20.90	40.10	9.66	.....	.....	.....	.....	29.64	24.10	46.25
28	.....	Cuban Ore	24.30	29.76	35.94	8.00	.....	.....	.....	.....	27.00	33 06	39.93
29	Bessemer	.....	34.48	13.89	44.33	3.09	.....	0.87[2]	.....	4.01	37.19	14.98	47.82
30	.....	Warwick, Pa	35.00	23.00	35.80	7.30	.....	.....	.....	.....	37.31	24.52	38.16
32	.....	Warwick, Pa	39.00	16.50	35.50	9.70	.....	.....	.....	.....	42.85	18.13	39.01
33	.....	Warwick, Pa	35.50	14.00	39.40	10.80	.....	.....	.....	.....	39.93	15.74	44.31
34	.....	Warwick, Pa	36.75	16.75	40.50	5.20	.....	.....	.....	.....	39.09	17.81	43.08
35	.....	Warwick, Pa	37.23	9.51	33.84	17.08	.....	.....	.....	.....	46.20	11.80	41.99
36	.....	Warwick, Pa											

37		Warwick, Pa.	34.37	15.27	43.13	4.74					37.04	16.46	46.49
38[7]		Lehigh District, Pa.	35.26	13.83	24.35	19.23		1.65	2.19	3.10	48.01	18.83	33.15
39		Lehigh District, Pa.	39.95	5.48	47.39	5.38		0.94			43.04	5.90	51.05
40		Lehigh District, Pa.	38.37	3.98	35.18	19.48		1.53		1.04	49.49	5.13	45.37
41		Lehigh District, Pa.	35.99	8.84	28.80	20.67		0.45	1.40	2.52	48.87	12.00	39.11
42		Lehigh District, Pa.	32.64	13.62	31.10	21.80					42.19	17.60	40.20
43[8]		Lehigh District, Pa.	37.40	11.40	21.91	22.37		0.85	1.20[5]	2.27	52.89	16.12	30.98
44		Pont-à-Mousson	31.84	20.64	43.12	2.49		1.03			33.30	21.59	45.10
45		Muirhead	28.70	25.60	29.40	13.00					34.28	30.58	35.12
46		Muirhead	27.00	20.10	40.90	11.10					30.68	22.84	46.47
47		Lorraine-Luxemburg	35.00	20.00	34.00	3.00		3.70			39.32	22.47	38.20
48		Lorraine-Luxemburg	32.00	20.50	40.50	1.00		2.00			34.40	22.04	43.54
49		Lorraine-Luxemburg	34.00	15.20	44.00	2.30	1.40	1.60			36.48	16.30	47.21
50		Lorraine-Luxemburg	32.00	22.00	42.00	2.00	0.70	1.00			33.33	22.91	43.75
51		England	43.00	14.83	29.00	5.57	1.30	2.50	1.90	1.90	49.52	17.07	33.39
52		England	31.46	8.53	52.53	1.38	2.38	0.76		2.96	34.00	9.22	56.77
53		England	27.38	22.23	40.12	7.27	0.20	0.80		2.00	30.51	24.77	44.71
54		Scotch Works, Average	35.00	17.00	40.00	6.00	1.50[1]		0.50		38.04	18.47	43.47
55		Scotch	29.00	19.00	38.50	8.50				5.50	33.52	21.96	44.50
56	Basic	Scotch	36.30	18.43	44.20	0.11		0.69			36.69	18.62	44.67
57		Dowlais	43.59	14.78	31.40	4.66	1.41[1]	1.06	1.91	1.93	48.55	16.46	34.97
58	Grey	Dowlais	38.48	15.13	32.82	7.44	1.62	0.76	1.92	2.22	44.52	17.50	37.97
60		Cleveland	36.50	22.59	32.68	5.83	0.32	0.06	0.96	1.74[3]	39.77	24.61	35.61
61		Scotch	29.00	19.00	40.00	8.50				5.50	32.95	21.59	45.45
63		Dahlkarlshyttan	53.15	1.66	35.95	6.82	0.48	1.67			58.56	1.83	39.61
64		Dahlkarlshyttan	56.00	1.90	34.70	7.00	0.10	0.20			60.47	2.05	37.47
65		Seglinsberg	57.80	1.48	27.60	9.55	1.47	1.13			66.52	1.70	31.76
66		Guldsmedshyttan	56.35	1.88	33.60	6.26	0.59	1.03			61.36	2.04	36.58
67		Gammel Kroppa	53.20	7.20	17.40	20.40	0.49	0.82	1.06	0.52	68.38	9.25	22.36
68		Gammelbo	53.60	6.40	22.30	16.40	0.57	0.68	1.06	0.52	65.12	7.77	27.09
69		Klenshyttan	53.40	10.70	30.60	3.00	0.38	1.29	1.06	0.52	56.38	11.29	32.31
70		Ulfshyttan	58.50	3.70	25.60	10.10	0.71	1.29	1.06	0.52	66.62	4.21	29.15
71	Charcoal	Jenbach	66.90	14.08	12.24	4.48	0.85	0.83		0.38	71.76	15.10	13.13
72	Charcoal	Pfeilhammer	56.10	5.20	21.78	7.21	6.30	2.70			67.52	6.26	26.21
73	Charcoal	Rubeland am Harz	53.79	13.04	25.67	0.57	2 20	2.44			58.15	14.09	27.75
74	Charcoal	Kolapatak Ungarn	53.40	7.65	17.00	13.40	5.17	1.07		0.95	68.41	9.80	21.78

[1]Mn only. [2]Fe only. [3]S only. [4]BaO. [5]TiO_2. [6]MnO+FeO. [7]Ultimate composition includes 5.00% spinel. [8]Ultimate composition includes 2.38% spinel

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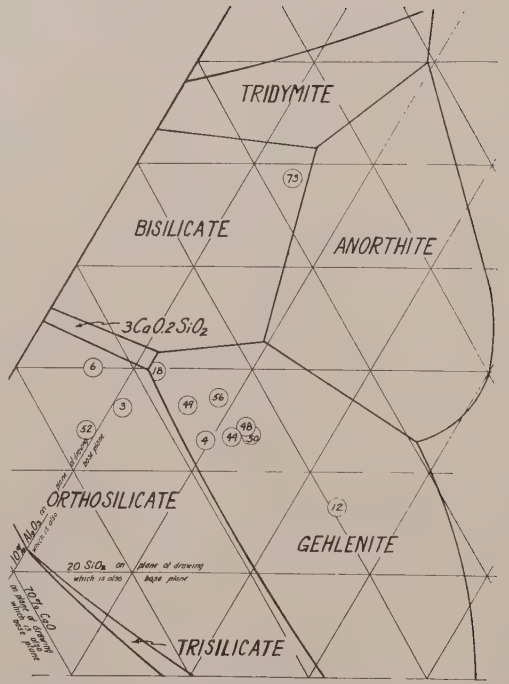

Fig. 6—Location of typical slags in fields of primary crystallization. Plane = 0% MgO. Slags, 0 to 2.5 MgO.

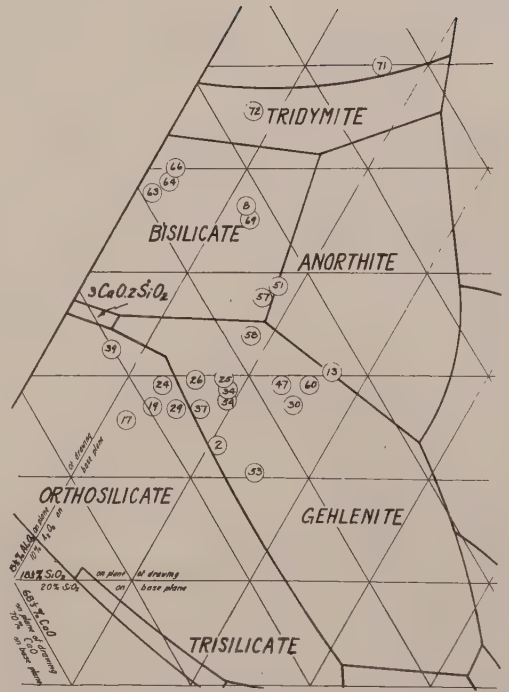

Fig. 7—Location of typical slags in fields of primary crystallization. Plane = 5% MgO. Slags, 2.5 to 7.5 MgO.

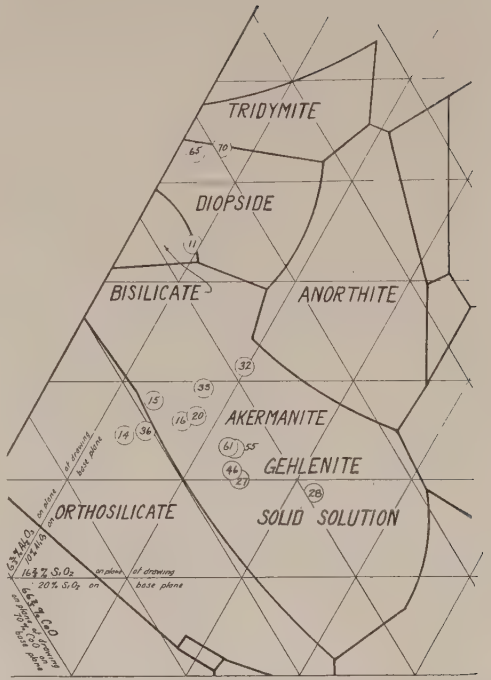

Fig. 8—Location of typical slags in fields of primary crystallization. Plane = 10% MgO. Slags, 7.5 to 12.5 MgO.

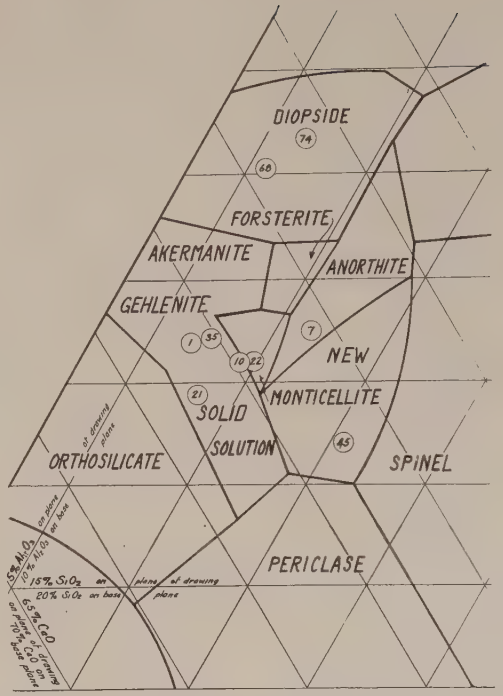

Fig. 9—Location of typical slags in fields of primary crystallization. Plane = 15% MgO. Slags, 12.5 to 17.5 MgO.

primary crystallizations and of high melting points is also plainly shown.

The space model demonstrates forcibly the fallacy of the old idea, that the addition or subtraction of CaO or MgO or Al_2O_3 or SiO_2 to a slag had the effect of changing the properties of the slag because the properties of these four primary components were changed, where as a mat-

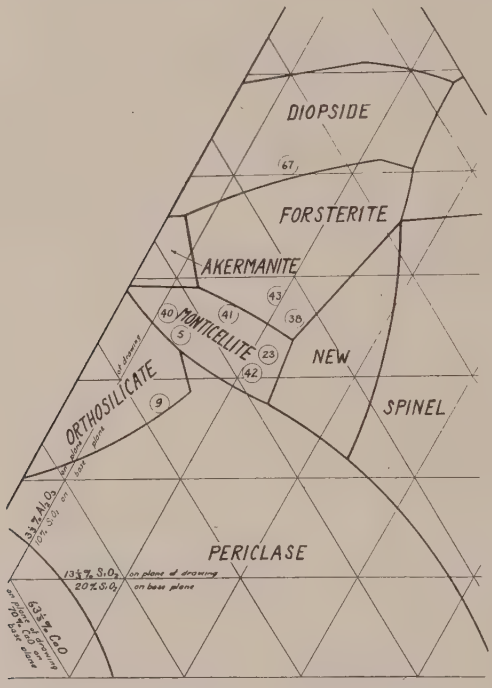

Fig. 10—Location of typical slags in fields of primary crystallization. Plane = 20% MgO. Slags, 17.5 to 22.5 MgO.

ter of fact a slag consists almost entirely of compounds of these primary components, and it is really the variation of the properties of these compounds that changes the properties of the slag. As the properties of the ultimate components are radically different from the properties of the compounds, the disastrous result of reasoning based on the old notion is made very evident.

As a result of our study of the constitution of blast

furnace slags, we believe we have at last given a scientific explanation of their constitution that fits in with known facts, that is in accordance with the latest ideas of physical chemistry, and which affords an easy and logical explanation for many things that had not been satisfactorily explained before. It also harmonizes many of the observations that had been made by furnace men, which seemed till now diametrically opposed to each other.

The fusibility or melting points of slags, the viscosity, the specific heat, the latent heat of formation and the solubility for sulphur are all properties which can be determined in the laboratory and if known quantitatively for those compounds or mineral entities which compose slags, would afford the blast furnace operator the exact data on which to base his slag composition and afford means for the accurate determination of the most economic operation of the process.

In this discussion of blast furnace slags, we have left iron and manganese oxides out of consideration in the first place to simplify the problem and secondly because we believe their effect generally will be to replace lime and magnesia. However, the effect of iron and manganese oxides is something which will have to be determined by future research.

THE CHAIRMAN: (Mr. Charles M. Schwab). Discussion of the paper will be by Mr. B. E. Pheneger, Assistant General Superintendent, Newburgh Steel Works, American Steel & Wire Company, Cleveland, Ohio.

Discussion by B. E. PHENEGER

Assistant General Superintendent, Newburgh Steel Works, American Steel & Wire Company, Cleveland, Ohio

We have just listened to a most interesting paper by Professor McCaffery on a subject which is always of vital interest to the blast furnace operator.

To give a critical discussion of his work would require an intimate knowledge of physical chemistry, mineralogy and crystallography. Professor McCaffery has approached this subject from a purely scientific standpoint with ideal conditions of pure materials and known quantities, while I will discuss the relation of this theory to actual practice using Lake ores, Connellsville or by-product coke and either local or Michigan limestone in which impure substances in varying quantities abound.

In blast furnace practice, as in some other metallurgical processes, the operator depends upon the appearance, the physical condition and the chemical analysis of the slag as an indication of the condition within the furnace and the kind of iron he may expect from the furnace. Uniformity of the slag indicates uniformity of the materials charged, of the handling of the furnace and that uniform iron may be expected.

Ordinarily the furnace operator deals only with the reported or ultimate slag analysis which covers the five principal components CaO, MgO, SiO_2, Al_2O_3 and S and does not concern himself with the binary, ternary, and quarternary compounds resulting from the first four named components, as these compounds cannot be determined in his laboratory.

All materials charged into the furnace even under the best possible condition of grading cannot be prevented from varying in chemical and physical structure as well as in analysis. The variations in stocks cause many variations in operation, which would not be encountered were ideal conditions in materials obtainable. It is highly improbable that such ideal materials will be available even though enormous sums be spent in their preparation and if spent it is doubtful whether the advantages gained will justify the expenditure. Other conditions, such as the grade of iron wanted, the condition of the furnace lining and the distribution of stock,

influence the operator in determining the kind of slag to carry.

Silica and alumina are present in all ores and in coke ash and must be fluxed with a base. Sulphur, which is added principally by the coke ash, must be removed in greater part by the slag. The operator knows that lime must be added to his burden to flux the silica and alumina present and to combine with the sulphur to prevent too much of that substance going to the iron; he knows that magnesia should be added to give increased

Fig. 1—Low magnesia slag.

fluidity and, where slag is used as aggregate, magnesia must be present to prevent slaking.

Fig. 1 shows a sample of low magnesia slag with vitreous surface and its condition after being exposed to the atmosphere for twenty-four hours. The analysis of this slag is as follows:

SiO_2	Al_2O_3	CaO	MgO	S	Mn
34.54	15.62	46.61	1.58	1.43	.72

Usually the acids SiO_2 and Al_2O_3 are assumed to be interchangeable as are the bases CaO and MgO but some operators object to this and all do after certain low limits are passed.

Professor McCaffery has proven by his work that this assumption is wrong. His proof is substantiated by the fact that in furnace practice, if dolomitic limestone is used in place of calcite, the operation with Lake ores is affected adversely and the removal of sulphur is lessened. Nineteen operators who were consulted agree that their practice is adversely affected if the magnesia content of the slag is allowed to go higher than 6%. One western plant discontinued the use of 20% magnesia stone and replaced it with calcite with the result that the tonnage immediately increased and at a lower coke consumption. One eastern plant, by a test continuing for several weeks, proved that the replacement of limestone with dolomite caused the slag to lose much of its desulphurizing effect after the MgO content passed 4 to 5%. Most blast furnace men have at times experienced operations with high magnesia slag with the result that the slags became less fusible, less fluid to the point of being gummy and sticky, with a tendency to build on the bosh of the furnace and invariably less able to eliminate sulphur from the iron.

High alumina content in the slag also has a decidedly detrimental effect on furnace practice. It usually results in making the slag very light and foamy, causing the furnace to melt high with hanging, poor practice and off-grade product. The slag becomes less fluid, the viscosity at times is increased and the melting point is lowered, which is often undesirable. The usual remedy for high Al_2O_3 is to add to the burden SiO_2 with the necessary limestone, which increases the slag volume and decreases the Al_2O_3 percentage. The consensus of opinion of the same nineteen operators is that the percentage of Al_2O_3 should not go above 15%, although two have had good results with 18%. There is a divergence of opinion as to the low limit for good practice but no one placed it below 10%.

Fig. 2 shows a porous sample of high alumina slag

and one of about 5% lower, taken within three hours. The analyses are as follows:

SiO_2	Al_2O_3	CaO	MgO	S	Mn
29.35	20.51	41.58	5.67	1.64	.75
34.38	15.38	43.15	4.87	1.59	.86

Two furnaces in the Pittsburgh District reported smoother operation, better quality of product and better practice with entire elimination of buckshoty slag, when the percentage of Al_2O_3 was as high as 25%. In both cases, however, it was in the presence of very low MgO and high CaO. Some furnaces have shown poor results as to quality of product and practice due to the formation of spinel (MgO, Al_2O_3).

Fig. 2—High alumina slag.

Most slags show crystals of spinel, but it is formed in appreciable amounts in furnaces only where both MgO and Al_2O_3 are high in the presence of very low SiO_2. Most of the ill effects of high MgO and Al_2O_3 can be overcome by increasing the slag volume, but this is not always desirable and is not economical.

Too much lime will cause operating troubles, but as this is absolutely under the control of the operator, it is not allowed to interfere with good practice.

It is true that a variation in the percentage of one of the constituents present will change the mineral com-

Fig. 3—Ladle of fuming high sulphur slag.

Fig. 4—Same ladle, twenty minutes later.

position of the slag, but it must be quite an appreciable variation in the ultimate analysis to have it affect the furnace practice. This is true of the larger furnaces particularly. One small hearth, flat bosh, short furnace in the Corporation will immediately perform very irregularly, with resultant bad practice and poor quality of product, when the ultimate analysis of the slag shows that the Al_2O_3 has increased above 14.5%.

Primarily the furnace man arranges his slag to make the furnace work smoothly, but of equal importance is the ability of the slag to absorb sulphur and the condition which allows the proper amount of silicon to go into the iron must not be overlooked. A slag is considered to be saturated if it holds 1.75% of sulphur and many consider that 1.4% is sufficient to require a re-arrangement of materials or additional slag volume. Percentages beyond 2% begin to show in the physical qualities and if 3% is reached the slags become unmanageable with resultant poor quality of product. In one instance where, over an extended period, the sulphur in the slag averaged 2.6% with a maximum of 3.57%, the use of a very basic slag at the rate of 1600 pounds per ton of iron did not give good product. Various changes to alter the ultimate analysis of the slag were made but no combination was found which would give the desired result.

Daily Average Slag Analysis						Resultant Iron	
SiO^2	Al_2O_3	CaO	MgO	Mn	S	Si	S
34.14	12.70	45.57	5.61	.49	2.67	1.28	.101
34.20	12.80	49.93	1.30	.30	2.78	1.84	.074
35.60	16.40	44.44	1.73	.36	2.74	1.78	.093
33.60	17.00	45.80	1.38	.52	3.60	1.65	.125
29.60	13.50	53.09	5.68	.20	3.57	1.54	.121

Fig. 3 shows a full ladle of fuming high sulphur slag and Fig. 4 shows the same ladle twenty minutes later. The analysis was as follows:

SiO_2	Al_2O_3	CaO	MgO	Mn	S
34.20	17.60	42.30	3.90	.30	3.35

It is a well known fact that high hearth temperature will produce high silicon iron unless it is held lower by

a very basic slag. The hearth temperature will vary with the refractoriness of the slag and with the amount of stove heat available; and the furnace can operate successfully with one kind of slag if the hearth is hot, while if the hearth were colder, off grade iron would result.

Fig. 5 shows two samples of slag of approximately the same analysis. The dark sample was made when the furnace was on the cold side, while the light sample was made on the same furnace six hours later, when the furnace was hotter.

Fig. 5—Slags from cold and hot hearths.

The presence of manganese in the burden and consequently in the slag also has a considerable bearing upon the kind of slag which gives the grade of iron required.

The work done by Professor McCaffery in making his space model from compositions found in primary crystallizations checks what the practical blast furnace man has used in his work for years, and further investigation and experiment with the four main components of blast furnace slag, together with sulphur and manganese, may develop information which will greatly benefit the art of making iron in a blast furnace. Most furnace operators are given certain materials to use

and do use them to the best advantage to obtain the product required of them. These materials are proportioned and supplied in accordance with what is now considered best practice. Even though these experiments are carried on under ideal conditions with chemically pure substances and known quantities, this scientific work done in connection with a technically trained furnace operator, might bring out facts which, when reduced to empirical formulae, might be of such benefit to blast furnace operations that it would be economical to spend large sums to prepare the raw materials with more care than is exercised at present and thereby make the process of making pig iron less costly.

The Chairman (Mr. Charles M. Schwab): Further discussion of the paper will be by Mr. G. M. Hohl, Superintendent of Blast Furnaces, Bethlehem Plant, Bethlehem Steel Company, Bethlehem, Pa.

Discussion by G. M. Hohl.

Superintendent of Blast Furnaces, Bethlehem Plant, Bethlehem Steel Company, Bethlehem, Pa.

It is an axiom among furnace men of both the old and the new schools that "if the slag is right, the iron must be right." While the importance of slag composition has been realized for so long, the actual why and wherefore of such importance remained obscure. Only in recent years have such terms as "temperature of slag formation," "critical hearth temperature," and "slag viscosity" been included in the blast furnace vocabulary.

For a long time the bulk of information on slags was based on experience. An operator happening to obtain a slag on which the furnace worked well, did his best to always have the same slag analysis. Similarly, information was obtained on slags of poor analysis. In this way a number of beliefs came to be accepted as true, such as the bad effect of high alumina content, and that magnesia replaces its chemical equivalent of lime.

The errors of these beliefs are gradually being shown

both in the laboratory and in the operations. Ores with a large alumina content have been used successfully, and can now be smelted with no more trouble than ores with the present normal alumina content. The conditions facing the blast furnace operator demand more exact knowledge of the furnace reactions today than ever before. With larger units and increasing demand for tonnage, there is too much dependent on every stack to permit any but the most economical operation.

It is believed that at most of the leading plants today the blast furnace raw materials are sufficiently standardized and uniform to make close calculations of furnace charges possible. The uniformity of ores and fluxes, and, at some fortunate plants, of coke, is the result of years of effort and study. Perfection has not yet been reached, but immeasurable strides toward it have been made in the past twenty years.

Mr. Pheneger mentioned the fact that the larger stacks are not so sensitive to changes as smaller stacks. This is due to the variations in analysis of the materials tending to reach an average on account of the larger tonnages handled.

Professor McCaffey's paper, which certainly must represent a vast amount of experimental work, gives exact data on the mineralogical composition of blast furnace slags. He shows that slags are made up of a combination of known compounds, each of which has properties differing from the others. The use of an equilateral tetrahedron to represent a four component system is very ingenious, and I feel sure that the model he has constructed and presents in this paper will be of value to the industry. He plainly states that this report is but the groundwork for more detailed research and experimentation.

The melting points, the viscosity, the specific heats, the latent heat of formation, and the sulphur carrying capacity, which he mentions, are of more direct interest to the operating man, than the mineralogical composi-

tion. I hope that these properties will be determined and shown as Professor McCaffery has shown the mineralogical composition. This report is the starting point on which future investigations are to be based, and as such must be thoroughly understood.

The quaternary system of CaO, MgO, SiO_2, Al_2O_3 is possibly of still more interest to Eastern Pennsylvania operators than to those in the West. The limestone in this region always contains 3% to 8% MgO, or else the stone charge consists of 50% dolomite. The slags in this district contain from 14% to 21% MgO, which is much more than is found in slags in the Pittsburgh or Chicago districts.

I cannot agree that 3 to 5% MgO in the slag should be the limit for good practice, as at Bethlehem the slags average 17 to 19% MgO and the sulphur in the iron is no higher, nor the coke consumption higher, than at plants using low magnesia stone. We do not use such a high percentage of dolomite by choice but because it has been shown to be cheaper than using all calcite, which is expensive in our district.

It will be interesting to learn the effect on the constitution of slags caused by the addition of MnO, FeO, CaS, K_2O and Na_2O. These last two oxides are present in small percentages in most slags, and should be considered, even in amounts as low as .20%.

Professor McCaffery's paper is a valuable contribution, and forms a sound basis for a real knowledge of slags.

The Chairman (Mr. Charles M. Schwab): We will now have a paper on The Manufacture of Tinplate in India, by Frank L. Estep, of Perin & Marshall, New York, N. Y.

THE MANUFACTURE OF TINPLATE IN INDIA

FRANK L. ESTEP
Perin and Marshall, New York, N. Y.

The building of a plant for the manufacture of tinplate in India was the final result of consideration given in 1916 to a market for new and additional products of the Tata Iron and Steel Company. The Steel Company had undertaken great extensions to their existing plant, with heavy increases in tonnage, and they wished to secure an immediate and nearby market for a large amount of the output in semi-finished form.

Investigation showed that tinplate was being imported into India, previous to the World War, at the rate of about 50,000 tons per year. A large percentage of this importation was used by the Burma Oil Company, for containers for petrol and kerosene. The largest can manufacturing plant and filling station of this company was located at Budge-Budge, on the Hoogly River, just south of Calcutta, where tinplate, imported principally from Wales, was made up into cans. Refined oil was brought in tankers from Burma to Budge-Budge, and the cans were then filled and distributed to various parts of India for consumption. During the War, tinplate was extremely difficult to secure and very high in price; deliveries were irregular and uncertain, and the operations of the Burma Oil Company suffered in consequence.

In view of all this, serious consideration was given by Messrs. Shaw, Wallace & Company, managing agents of the Burma Oil Company in Calcutta, and later by the Burma Oil Company officials in London, to the building of a plant for manufacturing tinplate in India. A test sample of the Tata Iron and Steel Company's steel was poured and rolled into blooms in India, the blooms

shipped to South Wales and there rolled into tinplate. The analysis proved satisfactory, and the resulting tinplates were of good quality. An agreement was entered into between the Tata Iron and Steel Company and the Burma Oil Company for the financing of this enterprise; the Tin Plate Company of India, Limited, was formed, and a decision reached early in 1920 to proceed with the building of a plant. A further understanding was had between the two companies regarding the supply of bars, electricity, water, etc., and a site decided upon for the tinplate plant, about three miles east of the steel company's new additions. The Tata plant is located at Jamshedpur (originally named Sakchi) on the main line of the Bengal-Nagpur Railroad, between Calcutta and Bombay, about 150 miles west of Calcutta, where the elevation is about 530 feet, and the latitude 22° North. The tinplate plant is called "Golmuri Works", after an Indian village which occupied part of the plant site.

It was early foreseen that, in order to operate successfully under the climatic conditions in India, the contemplated plant would have to be of special design and original in many respects. Perin & Marshall were entrusted with the design and construction of the plant as Consulting Engineers. They had the benefit of the knowledge of temperatures and humidity and also the experience gained from the design of the greater extensions of the Tata Iron and Steel Company's plant.

Generally speaking, the climate in this part of India is divided into three seasons; namely, the cold, the hot and the wet. The cold season extends from about October 1, or October 15, to about March 1, or March 15, approximately 4½ to 5½ months; the hot season, from about March 1, or March 15, to about June 15 to July 1, a period of 3 to 4 months; the wet season, from about June 15, or July 1, to about October 1, or October 15, approximately 3 to 4 months.

The rains stop early in October, the ground soon becomes dried of excess moisture, and the temperature

gradually approaches an average minimum temperature of about 51° F. in the early part of January, and the working conditions during the cold months are ideal. The hot season comes on uniformly but rapidly and reaches its maximum, as a rule, late in April or early in May. At this time the atmosphere has become very dry, occasionally under 10% moisture, and the maximum temperature will run from 105° to 120° F. in the shade at about three o'clock in the afternoon.

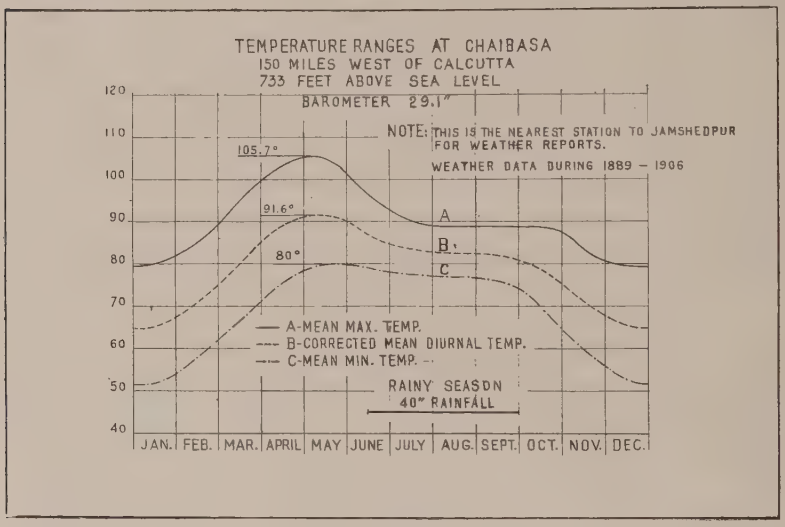

Chart No. 1.

The wet, or monsoon period, follows immediately after the hot season, and during the early stages the humidity becomes very high and has been continuously from 70% to 95% for two or three weeks. During the wet season it may rain almost every day, and in some seasons several times in a given day, the total rainfall over about 100 days being 30 to 40 inches. After three or four weeks of these rains, the temperature drops and continues fairly even until into September, when it gradually decreases again with the slackening off of the rains.

The variations in temperature and humidity are shown on Chart No. 1.

The highest temperature ever recorded at the Tata Iron and Steel Company's plant was in April, 1920, when for twelve consecutive days the maximum temperature in the shade recorded on their instruments, ranged from 120° to 127° F. The open-hearth department of the Tata Iron and Steel Company operated during this period. On account of the isolation of the tinplate plant, and the fact that it is near some low ridges thickly covered with jungle growth, the temperatures are about 4° to 6° lower, day or night, than at the Tata plant.

After a study of the total tonnage of imported tin plates and the amount used by the Burma Oil Company, it was decided to build a plant to produce a large percentage of the latter's requirements, and provide for future extensions, if and when found necessary and desirable, to take care of increased consumption by the Burma Oil Company, or the general market in India. It was estimated that the initial plant should produce 28,800 tons of black plate per year.

An ultimate capacity plant of four times this quantity was laid out first and carefully studied for continuity of movement of all materials during the process of manufacture without interference at any point, and this layout was then reduced to half the capacity and again studied for material movement and interruption to operations for the construction of the plant to the ultimate capacity. The decision being to build a plant of one-quarter the ultimate capacity, this was taken from the half ultimate capacity layout, and the buildings left in the positions required in the half ultimate capacity plant. The buildings for black pickling, black annealing, annealing furnaces, white annealing, cold rolling and power house need no extensions for doubling the present output.

Fig. 1, giving the general plan of the works, shows in full lines the plant as finally built, and in dotted lines the extension to twice the present, or ½ the ultimate capacity. At present, with the exception of one counter

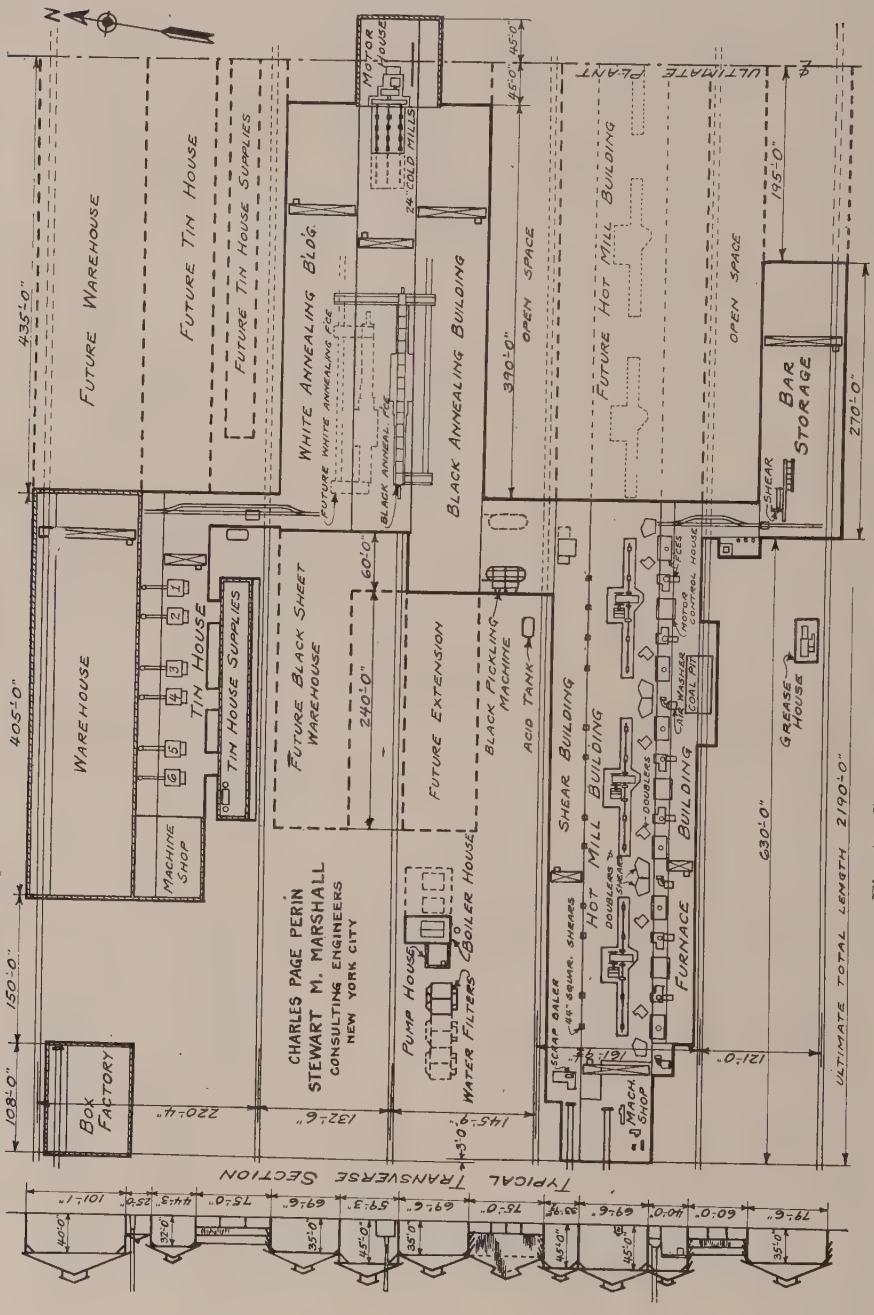

Fig. 1—General Arrangement of Tinplate Plant.

Fig. 2—General view of the Tinplate Plant from the southeast.

Fig. 3—View of buildings of Tinplate Plant, looking east.

movement, resulting from the utilization of one continuous annealing furnace for both black and white annealing, there is no interference in the movements of materials, and this interference will be eliminated when the second, or white continuous annealing furnace may be built. All materials for operation, incoming and outgoing, affect only the west, or left end of the plant as shown, and all additional materials for extensions can by-pass the present plant on the north side, and the construction will not affect or interrupt operations. Water supply lines, transmission poles, all main sewers, recirculating water pond and pumps, 95% of the tracks, foundations and motor capacity for cold rolls, foundations and underground cables for an additional motor generator set, and practically all main switchboards are now installed for twice the present capacity, or one-half the ultimate capacity. Fig. 2 is an external view of the present plant when practically completed, taken from the southeast corner, which will give some idea of the construction of the buildings.

It was already known by the engineers from experience with the Tata plant, that to keep the inside of the buildings as cool as possible in the hot months, they must first of all be extremely high and of large volume, with huge monitors, roofs with wide overhanging eaves, and the sides made with long louvre construction and left wide open wherever possible for a distance of ten to twelve feet from the ground level.

It was also necessary that the buildings be spread apart so that wherever possible they could be exposed on four sides for air. Reference again to Fig. 1 will show the spread of the buildings in relation to each other as built at the present time, and as they will be when the plant may be extended. The main buildings occupy a rectangular plot 801 feet 4½ inches wide by 1143 feet long, and the same area exactly will accommodate a plant of twice the present capacity. It will be seen from the elevation in the above view, that all main buildings are

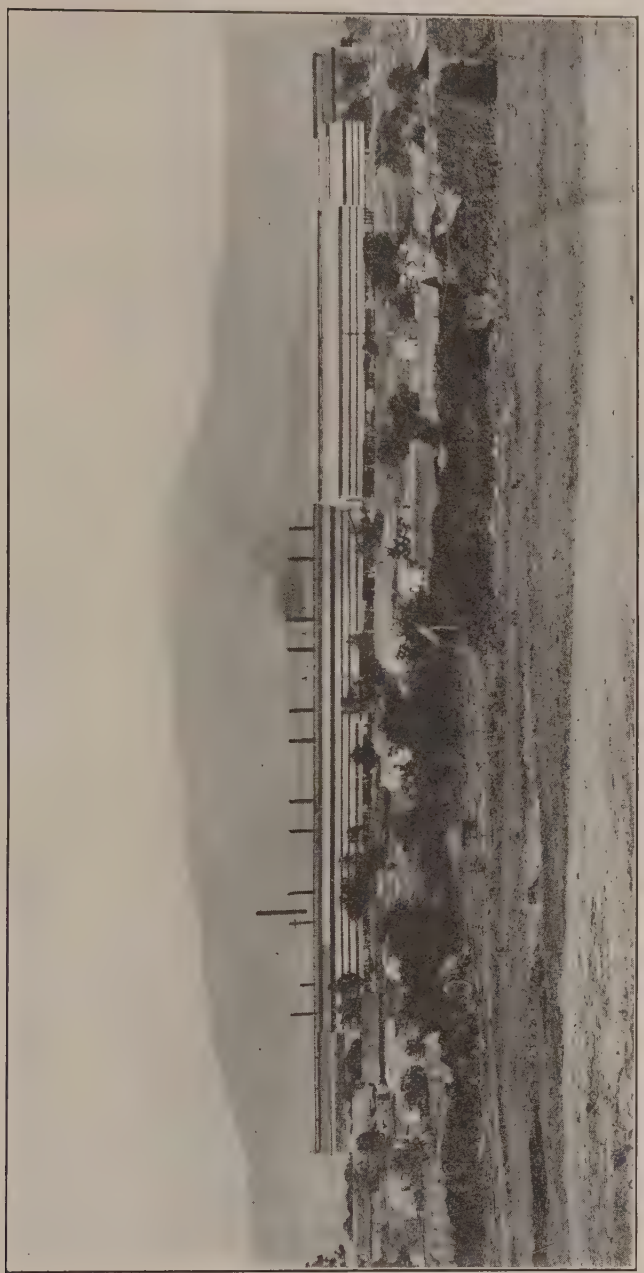

Fig. 4—General view of the Tinplate Plant, looking north, construction practically completed.

35 feet to the roof truss, except the furnace building, hot mill building proper, shear building, and annealing furnace building, all of which are 45 feet to the roof.

These buildings, therefore, are larger in volume than buildings in tinplate plants in the United States, and the furnace, hot mill and shear buildings, in addition to their extreme height, were stretched in length to give a wide spacing of mills. The hot mill building proper, covering two double mills per drive and six mills total, gives an average floor area per double mill of 90 feet by 69 feet 6 inches, or 6255 square feet per mill. In section the hot mill building proper has 3127.5 square feet to the bottom chord of roof truss, 505.5 square feet under the main roof, and 117.2 square feet under the monitor, a total cross sectional area of 3750 square feet. This is, therefore, a total volume of 337,500 cubic feet per double mill.

These floor areas and volumes per double mill of the hot mill building proper in India of 6255 square feet and 337,500 cubic feet respectively are to be compared with approximately 4400 square feet and 150,000 cubic feet per double mill in the United States. In other words, the floor area of the Indian hot mill is 42%, and the volume is 125% in excess of the American.

This also means that, assuming the tonnage heated and rolled in India to be only 75% of that for the same type of double mill in the United States, the floor area is about 90%, and the volume about 200% in excess of the American, per unit of heat turned loose in the atmosphere at and about the mills.

Since the tonnage to be produced and the probable ultimate success of the plant depended upon the continuous operation of the hot mills during all months, it may be well to describe at this point the other special provisions that were made in the hot mill proper, in addition to the large area and volume of buildings already mentioned, to insure operation regardless of temperature.

With the furnace building on the one side and the shear

building on the other side of the hot mill building proper, both being 45 feet to the roof chord, with the furnace building wide open twelve feet from the ground, with large louvres above, and with the shear building enclosed with large louvres to within twelve feet of the ground and enclosed from this point to the ground with small louvres, there is always a chance for external air to get into the hot mills. In addition to this, there is a large space between and above each furnace, allowing outside air to enter from the south through the furnace building, between and over the furnaces into the hot mill building

Fig. 5—Hot Mill Furnace Building.

proper, and carry the heat into the upper part of the building and eject it through the wide open monitor. If the wind is from the north, the heat is carried up into the furnace building, and out through its monitor.

Each pair and each double sheet furnace was completely hooded over, and each hood attached to a separate stack, larger in diameter and surrounding the draft stack, and extended several feet through the roof. Practically all the radiated heat from the furnaces, and smoke, flame and heat coming out from the doors when open, and much of the smoke and heat that arises from the

stokers at the back of the furnaces, are immediately carried by these hoods and stacks out of the building through the roof and discharged into the outside atmosphere. All furnaces have water-cooled fronts.

Between each unit of two double mills there is installed a fan of 36,000 cubic feet per minute capacity delivering 18,000 cubic feet to the men on each mill through underground ducts and eleven elbows. In terms of square feet of floor area, there is delivered approximately three cubic feet of air per minute per square foot of total floor area, or over 9 cubic feet of air per minute

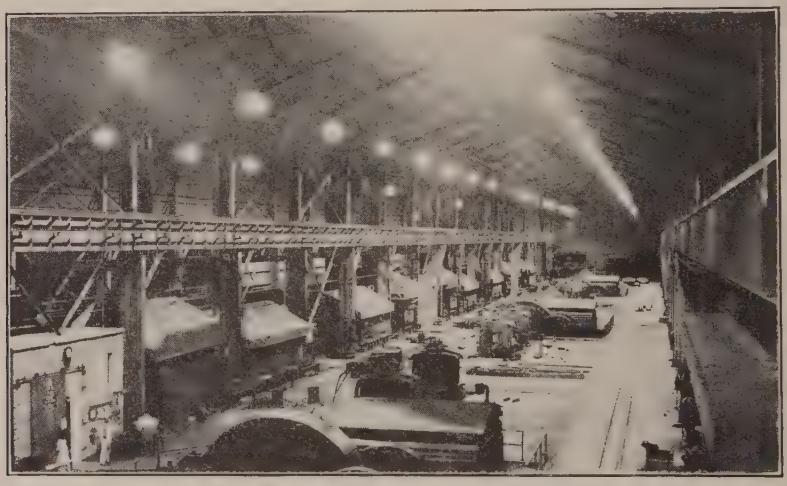

Fig. 6—The Hot Mill Building, showing the three double mill units, sheet and pair furnaces and motor control house.

per square foot of operating area. This means further over 400 cubic feet of air per minute per man.

Not being sure whether or not the men on the hot mills could stand up to their work better with a given quantity of hot dry air, or with the same quantity of air at a lower temperature and higher humidity, each of the fans was installed with an air washer on its suction. By this means any proportion of the total amount of air going to the men, from zero to 100% can be put through a spray and its temperature reduced. This was a very wise provision, and it may be positively said, that this

feature was practically the salvation of the hot mill, so far as its continuous operation was concerned during the first summer period of 1923.

The air washer was started the first of March, 1923, and comparative readings taken and recorded daily of the temperature and humidity of the outside air in the shade at about three o'clock each afternoon, and the temperature and humidity of the air discharged at the various elbows in the hot mill. In March the average maximum temperature was reduced from 91.9° to 77.3°,

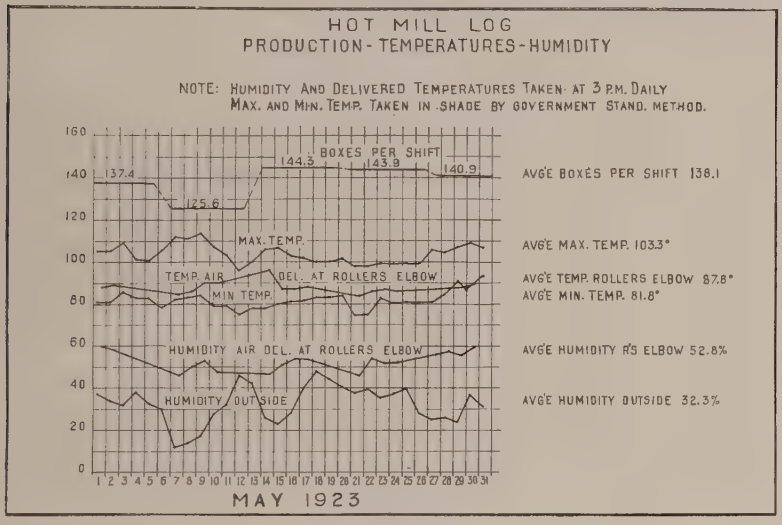

Chart No. 2.

and the corresponding humidity raised from 28.6% to 41.2%. In April the average maximum temperature was reduced from 104° to 87.1°, and humidity raised from 30.0% to 50.2%. One afternoon in late April, when the outside temperature in the shade was 109°, and the humidity less than 20%, the readings showed 80° at the elbows, a reduction of 29°. In May, the average maximum temperature was reduced from 103.3° to 87.8°, and the humidity raised from 32.3% to 52.8%. Chart No. 2 shows this data. In June, the first 23 days of which were hot and dry, and the last seven wet and cooler, the

average maximum temperature was reduced from 100° to 86.2°, and the humidity raised from 46.0% to 67.0%. It is worth while to note here that during July and August, the two worst of the monsoon months, the hot mill men preferred to keep the air washer on, and did not shut it down. This is illustrated by the following figures. In July the average maximum temperature was reduced from 90° to 86.1°, and the corresponding humidity raised from 60.9% to 72.3%. In August the average maximum temperature was reduced from 87.8° to 86°, and the humidity raised from 79.3% to 83.7%.

Special provision was also made by installing an exceptionally large area of water-cooled floor plates per mill. There are 1220 square feet per double mill, 270 on the back side, and 950 on the front side of each mill. These floor plates are cast iron, and although not as efficient in cooling as the welded water box plates, they have answered the purpose admirably. During the hottest periods in 1923, although the incoming water reached a temperature as high as 100° the discharge temperature of the water at the discharge weirs never exceeded 105°.

Attention is called to the fact that this very large area of water-cooled plates was not only beneficial to the men, so far as their being able to work on them was concerned, but the large area outside of the particular spots with which the metal came in contact, and upon which the men worked, held down the temperature at all times and forced the heat from about the men up into the building. That this statement is true and that the principle involved is applicable anywhere, is borne out by the fact that all grease fumes arising from the necks or steam from the body of the rolls of these mills in operation on these exceedingly hot days, rose straight up and quickly from about the mill. There was no cloud or haze or smudge hanging about the mills or in the building.

All of these features combined, volume of building, hooded and water-cooled furnaces, cool air in great quantities, and the excessive area of water-cooled floors,

made it possible to maintain operations at a very decent efficiency during the first summer operation, irrespective of temperature or humidity, both of which are far more severe than at any other tinplate plant in the world today.

Electrical power, three phase fifty cycles, is supplied from the Tata Company's station, about 3½ miles away, over a loop line, at approximately 3200 volts, generator switchboard, which drops to 2800 to 3000 volts at the tinplate plant. The incoming lines pass through an outside meter house, owned and controlled by Tata, containing cut-out switches, lightning arresters and recording integrating watt meter, and pass into the power house. Referring again to the general plan, this is a continuation of the building housing the annealing furnaces and cold roll department, has brick walls with concrete roof, a 10′ brick wall separating it from the cold rolls, which allows a 10-ton crane to serve the power house as well as the cold roll department.

The power house contains a 1,000 K.V.A., 750 K.W., 250-volt D.C. motor generator and the motor driving the cold rolls, together with the gear reducing set and gear train. There is also a motor driven compressor and a direct connected oil engine driven 12 K.W., D.C. generator unit for emergency use to generate direct current enough to throw the main oil switches, when and if the power goes off the main line and shuts the plant down. High and low tension oil switches and bus bars, transformers, etc., are located in a lean-to on the south side.

All A.C. auxiliary power apparatus is 440 volt, all cranes are D.C. and many of the individual machine tools, stoker drives, blowers and all tinning machines are driven with variable speed D.C. motors. Transformers are located at various points for low tension voltage for lighting, while a circuit at 3,000 volts leaving the tinplate power house switchboard carries current to Golmuri Town for lights and fans.

All electrical equipment, except some miscellaneous material and small motors, are General Electric Com-

pany make, shipped from the United States, and were on the ground quite some time before needed. Nearly every motor and transformer, when ready to install, showed by test a very low insulation resistance, but by very careful and long continued drying out, every piece was saved except the stator of one 10 H.P. motor.

The hot mill department consists of three units of two double mills each, one double mill on either side of the motor. The mills were furnished by the Mackintosh-Hemphill Company and each unit is driven by 1,000 H.P. American or about 850 H.P. Indian rating, 3,000 volt, 300 R.P.M. motor through a reducing gear set with very heavy flywheels, furnished by the Woodard Machine Company. The rolls are 28″ diameter and run at 33.2 R.P.M. Each motor has its own control room which is located directly opposite the motor itself, in a brick house in the furnace building. Each motor and control room is provided with underground air ducts for cooling from the same air system which supplies the men.

The cold roll department consists of four sets of rolls, three in tandem, also furnished by Mackintosh-Hemphill Company, the roughing train driven at 48 R.P.M., the intermediate at 50 R.P.M. and the finishing train at 52.6 R.P.M. from a 750 H.P., 3000 volt, 500 R.P.M. wound rotor induction motor through a gear reducing set and a train of five cut gears manufactured by the Woodard Machine Company. Foundations and bed plates have already been installed and the motor is of sufficient capacity to drive a total of seven sets of cold rolls in the future.

All rolls, hot and cold, were furnished by the Pittsburgh Roll Corporation.

All shears and roll lathes were furnished by the United Engineering and Foundry Company, while the pair furnaces, sheet furnaces, continuous annealing furnace and furnace cars were furnished by the George J. Hagan Company. The pair furnace pushers are operated hydraulically, as is also the Logeman scrap bundler.

Nine cranes total cover all operating departments, with the exception of the black pickling, and range in capacity from 5 to 15 tons. They were furnished by the Alliance Machine Company. All ratings are in long tons.

The hot mills were equipped with six "Steele" mechanical doublers for the roughers, and also six with shears for the finishers. These were furnished by the American Sheet and Tin Plate Company. Experience has proven that, without the mechanical means of doubling, it would have been impossible to successfully operate during the hot months on the two-roll, three-part system in India. The physical effort of hand doubling would undoubtedly have proven too great for any Indian, Europeans would have been unable to stand up under this work during the hot months, and the output would have dragged materially. Besides, it would have entailed the importation of at least twice the total number of Europeans for the hot mill proper, and the operating cost would have become prohibitive.

The black pickling machine is of the Grey type and was built by Taylor & Sons, Ltd. of Briton Ferry, England, and is the latest design of this machine.

Cast iron annealing bottoms and cast iron false bottoms were made locally in India to save freight, while the hammer welded annealing box covers were manufactured by the Blaw-Knox Company.

The white pickling and tinning is done on six Thomas-Davies combination white pickling, tinning and cleaning machines, manufactured in South Wales. These are installed in a building designed especially for them and erected rights and lefts with coal firing pits common to two machines, and so arranged that each machine discharges its tinned product directly into the warehouse for inspection. Each machine is completely hooded and connected to a separate stack which surrounds the tin pot stack. The draft was insufficient to pull out the heavy fumes and vapors, and suction fans were later on

installed with each hood. The hoods can be quickly removed by crane, to permit stripping the pots during repairs.

A miscellaneous lot of tools were furnished mostly from the United States for two machine shops and an electrical shop. The main machine shop is an extension of the west end of the hot mill building and contains roll lathes, planer, drills, lathes, shaper, milling machine, steam hammer, etc. An extension was built to the tinning house and tools installed for the repairs and maintenance of the tinning machines and pots. This shop is served by the same crane which covers the six tinning machines, and any machine part can be stripped out by the crane and taken into the shop for repair. The electrical repair shop is in the northeast corner of the white annealing building near the power house and is mainly for the repair and maintenance of switches, brushes, brush holders, stator and rotor coils.

The plant has nine parallel railroad tracks of standard 5′ 6″ gauge. The extreme center to center of these railroad tracks is 781 feet 4½ inches. The first, or south, track is for bringing in bars; the second for coal for the sheet and pair furnaces; the third for serving the main machine shop; the fourth for handling bundled scrap; the fifth for bringing in sulphuric acid to the storage tank for black pickling; the sixth for coal to the boiler house; the seventh for supplies such as tin, palm oil, fluxes, etc., as well as sulphuric acid to the storage tank for white pickling, and also to serve as a loading track for a future black sheet warehouse. The eighth track is to serve a box factory, while the ninth and last track is a depressed shipping track extending throughout the warehouse.

Back of the shear building there are two 150 H.P. B. & W. Ltd. boilers, purchased in England, provided for the installation of chain grate stokers in the future. Alongside of and adjacent to the boiler house there were built two sand filter beds, allowance being made for four

total. On account of the scarcity of water during certain months, all uncontaminated water from the plant is conserved and collected in a large reservoir, from which it can be picked up by pumps and returned into the system, and the water piping is so arranged that this returned water can be used in places where it does not need filtering.

For drinking purposes about the plant, for the Europeans in Golmuri Town, and also for water for the manufacture of ice and bottled soda, it was necessary to install, in connection with the sand filter, a chlorine system for purifying the water. For the equalization of water pressure and as a short period supply in case of emergency, a water tower was erected on the space adjacent to the furnace building. On top of this tank there is another tank for the storage of filtered and chlorined water as a supply to Golmuri Town, which tank is at sufficient elevation to send water by gravity to individual storage tanks located on the top of each house in Golmuri.

All the main buildings, forming the plant proper, are enclosed with a brick wall, inside of which are also located a timekeeping office and a general works office, the latter being located between the shear building and tin house supply building. Outside of the wall at the southwest corner there is an ice making plant of two tons per day capacity and a soda water manufacturing and filling plant. South of and opposite the southeast corner of the wall, on the entrance side of the plant, it was found necessary to erect a fair sized emergency hospital, medical supply room and attending doctor's living quarters. Also, in the same general direction from the plant but farther away, there was erected a very fine general office, where all accounting, etc., is done.

Since the entire section of the territory where the plant was built was originally nothing but a jungle, and since it was known that about 100 Europeans would have to be imported into India for the operation of this plant,

it was found necessary to put up a complete European industrial city, and three or four new and modern Indian villages, for the housing of the higher class and better paid Indian and Eurasian labor.

The European town is on a hill higher than the works, located about one mile due south, and embraces a plot of ground of about fifty acres. There were built one agent's bungalow, one works manager's bungalow, forty-nine workmen's bungalows and one hotel. Each has its own compound, or yard, from one-half acre minimum to two acres maximum, and the fifty-two buildings have a total compound acreage of 36.25 acres. Some of the workmen's bungalows have two bedrooms and two living rooms, some have two bedrooms and one living room, and a few have one bedroom and one living room. All bungalows have large and wide verandas, all facing northeast, north or northwest.

Every room in each type of bungalow has one or two ceiling fans, also each veranda. These fans will average about seven per bungalow and are 52 inches in diameter, with variable speed control. They are absolutely necessary for the comfort of men living in the bungalows in the hot dry months, and all current for lighting and fans is individually metered to each bungalow, and the men pay for current used at cost to the Tin Plate Company.

The method of handling and the movement of materials through the plant during the process of manufacture, from bars to finished tinplate, is as follows: Bars, brought in from the Tata Company's plant are unloaded by a spreader beam crane in the bar storage building, placed when wanted at the bar shear, where they are cut to the desired length. Cut bars are loaded on bar carriers, picked up with the crane, stacked on a truck and weighed as they pass into the furnace building. Here the bar carriers are placed by a five-ton crane back of the six continuous pair furnaces.

Coal is emptied into a large coal pocket from the

track outside of the furnace building, and a grab bucket on the furnace building crane delivers coal into hoppers which will hold about one and a half tons each and feed the individual stokers by gravity. Ashes are collected in cars on an industrial track, which passes out across the yard through the enclosure wall, and are dumped in the neighborhood of the return water pond.

Scrap from the mechanical doubler shears, as well as all of the scrap from the squaring shears, is collected in large steel buckets, carried with the mill crane or the

Fig. 7—The Shear Building.

shear building crane to a point opposite the scrap baling press, which is located in an extension to the shear building. A three-ton monorail Shepard hoist covers the baling press pocket, and extends out of the building far enough to cover three railroad cars.

Black plate is opened adjacent to the shears, placed on special carriers and conveyed by overhead crane to a point opposite the black pickling building, and here placed upon small hand trucks. These trucks pass over a scale, and all plate leaving the opening floor is weighed as it enters the black pickling department. This is the only trucking point deliberately left in the scheme of

material movement, if the plant be doubled in capacity, except the necessary trucking in the warehouse itself.

In operation of the black pickling machine the crates make an elliptical movement into one acid and two water tubs, and at the discharge end of the circuit the crates are unloaded and the plates passed over the inspection benches, which are located directly underneath the crane runway, and then stacked without further handling onto the annealing bottoms in the black annealing building. The plates are placed on false bottoms which set on the

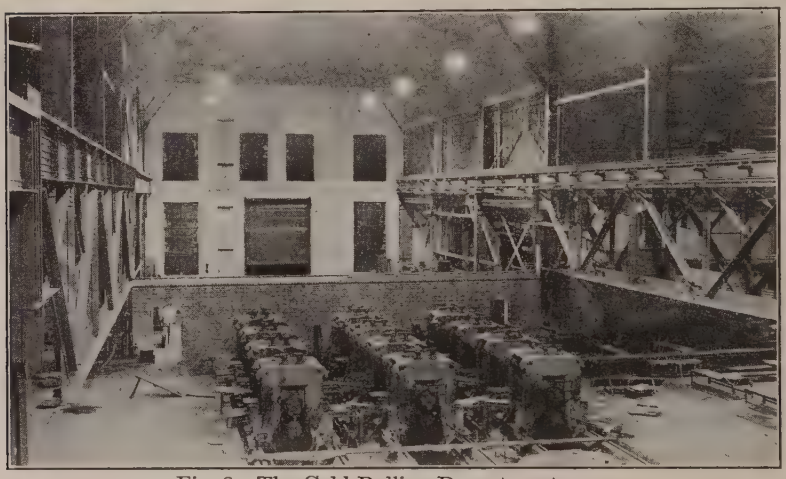

Fig. 8—The Cold Rolling Department.

annealing bottom proper, and their use has proven of very great benefit.

After the plates are flushed with a hose and the bottoms covered and sealed, they are picked up with a 15-ton crane and placed on a furnace car, which in turn sets on a transfer car, at the entering end of the black annealing furnace. After passing through the furnace for black annealing, the furnace cars are discharged onto another transfer car at the other end of the furnace, which brings them back into the black annealing building. When cooled, the annealing bottoms are unloaded opposite and in front of the cold rolls, and as the plates are cold rolled they pass across the furnace building and are again

stacked on annealing boxes back of the last train of cold rolls in the white annealing building.

At this time and for the present capacity of the plant, the boxes when loaded with cold rolled plate are transferred back into the black annealing building, and are passed through the same continuous furnace for white annealing, but the transfer car discharges them this time into the white annealing building. Later on, when a white annealing furnace is installed, these boxes will pass through for white annealing in just the same manner as is done in the furnace for black annealing, except that

Fig. 9—Thomas & Davies automatic feeding, pickling, tinning and finishing machines.

the movement will be in the opposite direction, thus bringing the plates after white annealing out at the end of the white annealing building opposite the cross building leading to the tin house.

When properly cooled the white annealed bottoms are picked up with a fifteen-ton crane, put on a car, and after passing over a scale and being weighed, are delivered underneath a ten-ton crane in the tin house. This crane picks up each false bottom with its load of white plate, or the bottom with the entire load, and sets it down in front of either of the tinning machines. Here the

plates are removed from the piles, are sanded and placed in the feeding pockets of the tinning machines.

From this point until they are picked up in the warehouse and placed on the inspection benches, the plates are not touched or handled, and, as compared with even the best practice in the United States, approximately five handlings total have been eliminated between white annealing and inspection.

The plates go through the Thomas and Davies machines in four streams for wide plates and eight streams for narrow plates, and are pickled, swilled, tinned,

Fig. 10—Warehouse.

cleaned, collected on a cross conveyor at the discharge end of the machine, and brushed with rotary brushes. The plates are then changed in direction of movement ninety degrees, again brushed with rotary brushes (this time at right angles to the previous brushing), discharged from this brushing machine onto a belt conveyor and go through a slot in the wall into the warehouse, where they are picked up in piles and placed on benches for inspection.

In the warehouse the plates are inspected, slit, counted, boxed and sealed in "wasters," and are held

on the floor ready for shipment to Calcutta. It was originally thought that it might be possible to do away with this sealed container and ship in wooden boxes, but on account of the severe rains and moisture over several months of the year, it was finally decided to seal all shipments and not attempt to use boxes. The sealed containers are not incased in any wooden box and therefore the box factory building has, up to date, not been used, except for store room purposes.

Clearing of the site for the building of the plant proper was begun in January, 1921, but not much work had been completed before June 15, 1921, when Mr. J. W. Bell was appointed superintendent of construction. About thirty-five per cent of the total volume of heavy concrete had been put in, which represented only fifteen to twenty per cent of the actual concreting work, and only one railroad track was in position, and sufficient space had not been provided by June for the unloading and storing of imported materials which would soon begin to arrive. There were received and erected a total of about 4,200 tons of structural work and about 4,000 tons of machinery, over ninety per cent of which had been imported from the United States and England, via Calcutta. This structural steel, together with the buildings for the Tata extensions, made a total of about 32,000 tons of fabricated steel, all of which was furnished and erected by the McClintic-Marshall Company, and at the date of contract was the second largest amount of fabricated steel ever contracted for in the United States of America.

Construction had proceeded far enough to make possible the first attempt at starting one hot mill on December 18, 1922, and the final and successful starting up of the first hot mill took place January 1, 1923. The second hot mill was put into operation January 29, 1923. Black plate was opened, stacked and covered, and all energies bent toward the completion of the rest of the plant.

The annealing furnace was completed and put into operation and the first set of cold rolls started late in

April, 1923, and the first run in the tin house on one machine was during the week ending May 5, 1923. The second tinning machine was started during the week ending July 7, and from that time on the annealing furnace, cold rolls and tinning house were able to make headway against the accumulation of black plate.

The entire plant was completed in construction and ready to operate at capacity by September 1, 1923, and between that date and December 12, 1923, the remaining four hot mills were successively and successfully started up, and the plant was in full operation one week less

Fig. 11—Left to right, Messrs. Samson, Leyshon, Estep and Bell.

than one year from the date of the initial attempt at starting one mill.

In July, 1922, when it was hoped to start operations by about October 1, it was decided to secure a works manager and a hot mill superintendent for this plant who had had experience on this type of mill in the United States. There are comparatively few mills here equipped to operate on the two-roll three-part system, the majority being the straight-away American system, roughing and finishing on one pair of rolls. These two men, Mr. John Leyshon and Mr. David Samson, were secured

from the Gary plant of the American Sheet and Tin Plate Company.

For the remainder of the European or covenanted staff it was thought entirely practicable and advisable to secure experienced tin workers from Wales. Steps were therefore taken by the writer in London in August, 1922, to have the Confederation of Labor approve a proposed contract for these men, whereby for an average service of three years in India they were to be paid an acceptable guaranteed wage independent of tonnage produced, with a further understanding that a satisfactory bonus should be worked out and adapted after the mills had started operation, and it was seen how Indian labor could be trained. The bonus for the hot mill men was to be based on production of good black plate over and above some pre-determined limit of boxes per shift, while other covenanted employees were to benefit in somewhat the same manner as the hot mill men, dependent upon quantity and quality of product, loyalty of service, etc.

A total of about ninety men were secured from South Wales. There were fifty-four experienced hot mill men, 24 heaters, 21 rollers and 9 helpers, making one full crew of eighteen men per shift for one hot mill. It was further proposed, and all the men understood, that later on, as the various mills came into operation, this total of fifty-four Europeans were to be divided and reduced in number per shift according to the number of mills in operation; further, that their duties would be, not only to perform the work of rolling, heating, doubling, catching, etc., but that they should also use every effort to teach the native to do all the various jobs in connection with hot mill work.

The remainder of the men from Wales consisted of foremen for various departments, such as bar storage, hot mill, shearing and opening floor, pickling, annealing, cold rolling, tin house and warehouse; also mechanical

engineer, electrical engineer, roll turner, millwrights, etc.

Many of the men were slow in becoming accustomed to the climate, and considerable sickness was prevalent throughout the first year. Some men became so incapacitated that they were sent home, a few were deliberately let go, and three died—two of heat prostration in June, and one from an accident. There were left for the operation of two mills during the summer months of 1923, up to and including the starting of the sixth mill on December 12, only 43 of the original 54 hot mill men. This number has since been increased to about fifty men.

Most of the men were quite happy and content, satisfied with their jobs, their wage and bonus, and very enthusiastic about the new plant in which they worked, and took readily to the method of rolling, etc. They gave full and loyal co-operation in teaching the Indians their jobs from the initial start of the plant. In order to start the last four mills in quick succession it was necessary during the summer to train an extra large number of Indian employees for all the various positions in the hot mill and keep them on the pay roll so as to have them available for filling out the crews when additional mills were started.

The first bars for the tinplate plant were rolled by the Tata Iron and Steel Company in November, 1922, and the analysis and quality of steel furnished have been excellent from the very start. Certain difficulties were encountered in their early efforts in regard to furnace scale and uniformity of gauge, but these were quickly overcome. A Government Inspector has been employed to pass on analysis, surface, and foot weights from the beginning. In order to relieve their old 16″ bar mill, upon which the tin bars were being rolled, the Steel Company started making short bars, cut to exact length, on their tandem plate mill, beginning in May, 1923. Bars from the plate mill were furnished continuously from that date

until January, 1924, when they started their new blooming mill and continuous sheet bar and billet mill.

The starting up of the hot mills was a most interesting procedure. Although 54 first-class hot mill men had been taken from Wales, only one man of the entire lot had ever rolled on a double mill in the United States, and he only as a rougher, while four other men had worked here as rollers or heaters.

Many things in regard to hot mill operations in India were entirely new to them, among which were the diameters and speed of rolls, and the rolling of packs from

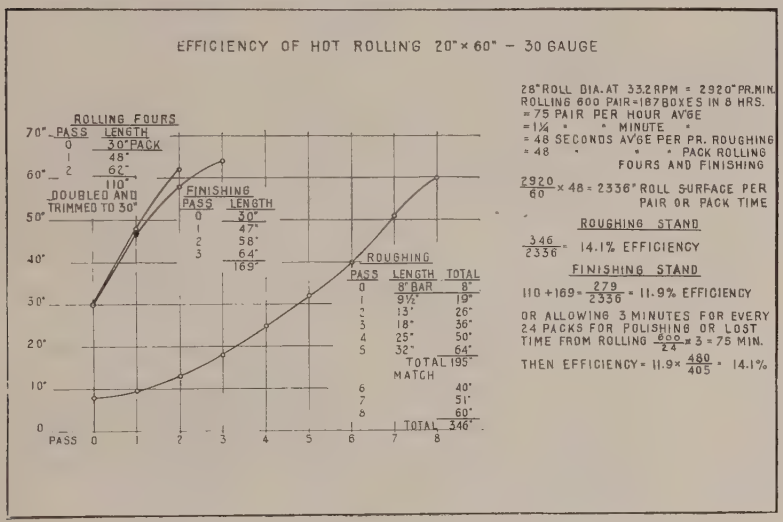

Chart No. 3.

pairs instead of from a single bar. Furthermore, they had never had to contend with the control and balancing of temperatures and contour between roughing and finishing rolls. They had been accustomed to rolling packs from single thick bars heated five times, two rollings and sometimes only one on the roughing and consequently there was no difficulty in regard to condition of the finishing rolls. Here a pair of thinner bars had to be completely roughed from the original heat on the roughing stand ready for doubling into fours, while the finishing

stand had only two passes on fours, and two or three finishing passes on eights, and the control of condition of the finishing rolls was more difficult. Note Chart 3, which shows graphically how completely the roughing and finishing stands are balanced in per cent roll efficiency when working the two-roll three-part system.

All of the rollers had been accustomed to running with very tight screws and very hot necks, and it took practically three months for the best of them to adapt themselves to a loose screw and catch on to the necessity for and the use of steam on the rolls and water on the necks for control of temperature and contour. The idea of polishing the finishing rolls after every heat of 24 to 32 packs seemed to them at first to be a waste of good time and entirely unnecessary.

The heaters were not used to furnaces of the type and design installed, either pair or sheet, and very few had ever had occasion to use stokers, while the coal which they have in Wales is far superior to anything available in India. The best coal possible was purchased for the initial start, and they soon became accustomed to handling both stokers and furnaces. All of these things were more or less of a handicap, but the men were patient and readily took suggestions and help from the works manager and hot mill superintendent, both of whom had had experience on this type of mill.

The initial start on the first mill was made December 18, 1922, and on account of doubler troubles and the holiday season, it was Monday, January 1, before the first mill went into operation for good. In the second week, the men thought they had reached the limit of mill and crew capacity, when 500 pair of 30 gauge were made on one shift, rolled 18¾″ x 56″. On Wednesday of the third week of operation, by special inducement, the three shifts made in succession, first 608 pair; second, 704 pair; third, 742 pair, all 18¾″ x 56″. There was some, but not much, bad black plate in these three shifts. The men thus very early found out that the furnaces and

mills had a capacity far beyond the limits of human endurance. Nobody could ever have made them believe that over 700 pair could be rolled in eight hours, but after their own demonstration they had to accept the fact.

On August 30, 1924, one turn on one mill rolled 820 pair and the following shift rolled 830 pair on the same mill, both shifts making 18¾″x56″ of 30 gauge.

Fig. 12—The first Indian employed in operation.

When the second mill was started January 29, 1923, there were about seven Europeans on the average per mill per shift, there being considerable sickness at this time, and the crews were filled out with Indians. It had been the intention to keep only two hot mills on during the first summer. There were many conditions to meet and overcome during the hot and wet months, and there

was nothing to go by as to what might happen during those months.

The largest week's output on two mills was made during the week ending September 1, 1923, when fifteen shifts turned out 4483 boxes, an average of 149.4 boxes, or 7.07 tons, of sheared black plate, per mill per shift, practically all 18¾″x56″, 30 gauge. Incidentally in a previous record week, ending April 28, 1923, when 4,437 boxes were made, the entire week's run was made without changing rolls. The greatest 24-hour output on two mills was on Tuesday, August 7, 1923, when 995 boxes were

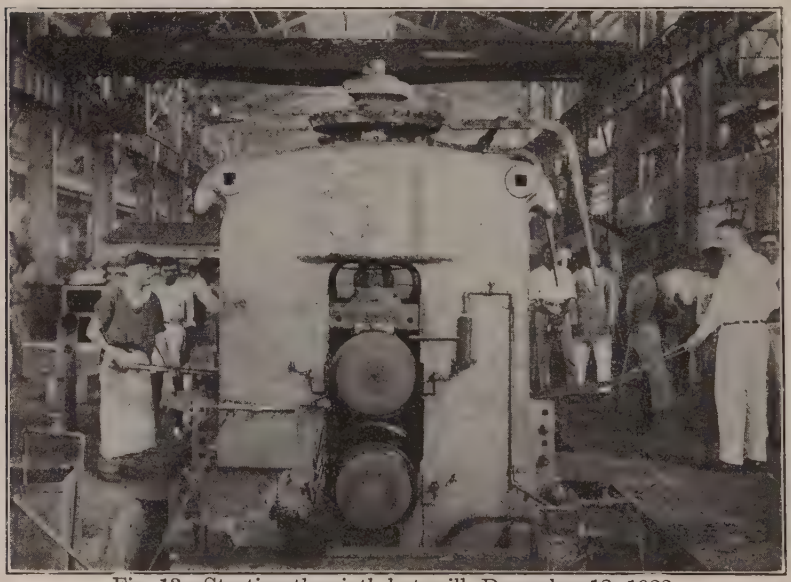

Fig. 13—Starting the sixth hot mill, December 12, 1923.

made, an average of 166 per mill per shift. The outside temperature was 77° minimum, 92° maximum, with the humidity 72 per cent, while in the afternoon the air to the men was at 86° and humidity of 79 per cent.

The third mill was put in operation on September 3, the fourth, October 15, the fifth, November 14, and the sixth, or last mill, on December 12, 1923. It is interesting to note that there was very little change in the average number of boxes produced per mill per shift during this

period. Extremely careful efforts were put forth by the hot mill superintendent and foremen and covenanted European employees to efficiently train enough Indians to take the various positions opened up by the starting of each additional mill. Attention is called to the further fact that these last four hot mills were started up and successfully put into operation with what was left, viz. 43 out of the original hot mill crew of 54 men. The six mills are now running with less than three Europeans per mill per shift on the average.

For the last week of two-mill operation, the average production was 149.4 boxes per mill per shift, on 15 shifts; for the last week of three-mill operation, 143.1 boxes, for the last week of four-mill operation, 132.6 boxes; for the last week of five-mill operation, 131.8 boxes. The sixth mill was started on a Wednesday, and for the first full week of fifteen turns on six-mill operation, the average production per mill per shift was 132.9.

For the entire year of 1923, there was hot rolled a total of 213,940 base boxes, an average of 131.5 boxes per mill per shift. The best total week's production on the hot mills for six mills was for the week ending August 30, 1924, when a total of 12,910 base boxes was rolled in fifteen shifts, or an average of 143.14 boxes per mill per shift. Based upon the operation of the plant up to date it is conservatively estimated that for fifty weeks operation the plant will have a capacity of 600,000 boxes minimum to 700,000 boxes maximum per year.

In regard to the hot mill rolls, the first shipment left the United States October 8, 1921, and the last shipment March 16, 1922. All these rolls had laid in the open at the works until the plant was up and the roll lathes ready to turn rolls. This aging and slow annealing process has resulted in a very long life, and up to January 1, 1924, only five hot rolls had been broken. This is a good record considering that as early as March, 1923, in the third month of operation, Indians were be-

ing taught to rough and four roll, and naturally several pairs of tongs were rolled. There had been rolled 31,721 boxes of black plate before the first roll was broken.

The cold rolls were started one set at a time until all four sets were in operation, by borrowing men from the hot mill during the time that Indian labor was being taught. Upon attempting to operate with all Indian labor, it was found that the production could not be maintained at anything like what it should be.

The Indian, although very adept and very capable when it comes to doing the same operation over and over again, could not set any pace for himself, and the difference that was found between the use of Indian labor on the cold rolls and Indian labor in the hot mills was principally that at the hot rolls there were a number of white men interspersed among a given number of Indians constituting a crew, and the white men set the pace.

It was, therefore, found necessary to do something radical at the cold rolls, and a feeding belt conveyor was designed and built for trial on one set of cold rolls, thinking that it would solve the problem. This device was a success from the very start, one set of rolls handling 550 boxes in seven hours on the third day of trial operation. Additional conveyors were built as fast as possible and installed so that since the week of January 26, 1924, all four sets of cold rolls have been operated with feeding conveyors.

The greatest output on any one set of cold rolls was during the week ending October 27, when in six days of eight hours, one set equipped with a feeding conveyor cold rolled 3900 boxes, and the best week's record for the same number of hours' operation on the four sets of cold rolls, all equipped with conveyors, was for the week ending February 2, 1924, when a total of 12,466 boxes were cold rolled.

There were tinned during the year 183,080 base boxes of which 143,838 boxes were "primes," 37,292 boxes of "firsts," and 1950 boxes of "seconds." The black and

white pickling for the year was done with a consumption of seven pounds of sulphuric acid and the tin yield was 1.69 pounds per base box.

The first week's output on the first tinning machine during the week ending May 5, in 128 hours of operation, was 2720 boxes, while the same machine on its second week's run, turned out 3067 boxes in 120 hours of operation. The record up to date on two machines is 6007 boxes made during the week ending September 8, 1923, in 120 hours of operation; the best record on three machines was 9038 boxes, made during the week ending November 3, 1923, in 117.7 hours of operation; and the best week's output on four machines was 9,754 boxes during the week ending, January 19, 1924, in 119.1 hours of operation.

The first shipment of tinplate was made to the can making factory in the latter part of May, and since previous to this date there had been only a few test sheets made into cans, the report of the inspection and the working up of the shipment were awaited with great interest. The inspection of this lot was very severe and by close analysis it was found that the majority of the trouble with the first shipment was due to improper packing, but the entire rejection out of the first lot was only 1.60 per cent.

In addition to the report made by the manufacturing plant and the filling station, the managing agents, Messrs. Shaw, Wallace and Company, had five consignments of petrol put up in cans made from this plate, shipped by rail to five distant and widely separated points in India, and asked for a report from the distributing agents. Four of these reports were decidedly in favor of the cans made from the Tin Plate Company's tinplate, as compared with previous shipments in cans made from imported plate, and based their decisions upon the number of leaky cans, the total amount of oil lost from leakage, the number of battered-up cans and the general appearance of the can.

It may be of interest to note here that in most countries, particularly in the United States, tinplate is made to answer one primary purpose only; namely, that of making up a container to hold some specified article. When this container has once been emptied it is thrown in the waste pile, and probably 80 per cent minimum of the amount of tinplate used has no second-hand value whatever, not even as scrap. In India, however, especially when tinplate is made into rectangular two Imperial gallon petrol cans and shipped over the country, the empty tin cans have a very high second-hand market value, and all these cans are very carefully preserved and sold into the "bazaars," or markets. Here the native buys one to several dozen of cans, cuts them apart and beats them up into all manner of articles, such as cooking utensils, water basins, drinking cups, ornaments, and even makes him a house of it. He, therefore, wants a fine quality and a good looking plate, and there is no doubt that an inferior quality of oil could be sold for a higher price simply because it has a better appearing can.

The result of the above fact is that, whereas the Tin Plate Company of India, Limited, could make a tinplate with a less coating of tin which would answer the original purpose of making an oil can and safely transporting petrol for use to some far distant point, they are still faced with the fact that they must have a good appearing can in order to meet the high second-hand value.

The factory report on rejections for the week ending August 11, 1923, is interesting. While the total percentage of rejections for all reasons was only .62 per cent, 1064 sheets out of a total of 2276 sheets were rejected on account of "undersize." This was 46 per cent of the whole amount rejected and was due to poor slitting, and was corrected at once. When the sheets come into the warehouse they are somewhat rounded on the front and back ends from the extreme stretch in the cold rolls, and the Indian operators on the slitters had been

unable to make allowance for this particular feature and the warehouse inspector had not caught it.

REJECTIONS, WEEK ENDING AUGUST 11, 1923

Cause of Rejection	Number of Sheets		
	Sides	Ends	Total
Rusty	30	113	143
Buckled	744	183	927
Undersized	1,054	10	1,064
Thin	10	...	10
Thick	2	...	2
Damaged from wagon rivet heads	130	...	130
Total rejections	1,970	306	2,276

Boxes used:

18¾″ x 14″	1,971 boxes
20″ x 10″	545 boxes
Total	2,516 boxes

Percentage of rejections—0.62 per cent.

The idea of manufacturing tinplate in a climate such as in India was very severely censured, and by many it was considered to be an absolute impossibility. In closing it may be said in all justice to everybody concerned, that the success of the plant up to date is primarily due to two things:

1.—To the very careful study and forethought given to the layout, to the design of buildings, and to the type and arrangement of equipment provided. Also, to the special provisions for taking care of the comfort of the hot mill crew proper, all of which have been recited above, consisting of hooded and cooled furnaces, large volumes of cooled air to the men, and tremendous areas of water-cooled floor plates per mill and per unit of heat.

2.—To the untiring efforts of the works manager and the hot mill superintendent, who had to face not only the problem of teaching a native, who could not understand their language, how to do an extremely difficult job, but who also necessarily had several months of constant effort in connection with the proper adjustment of experienced Welsh tin workers to the particular type of mill and system of working required. These two men

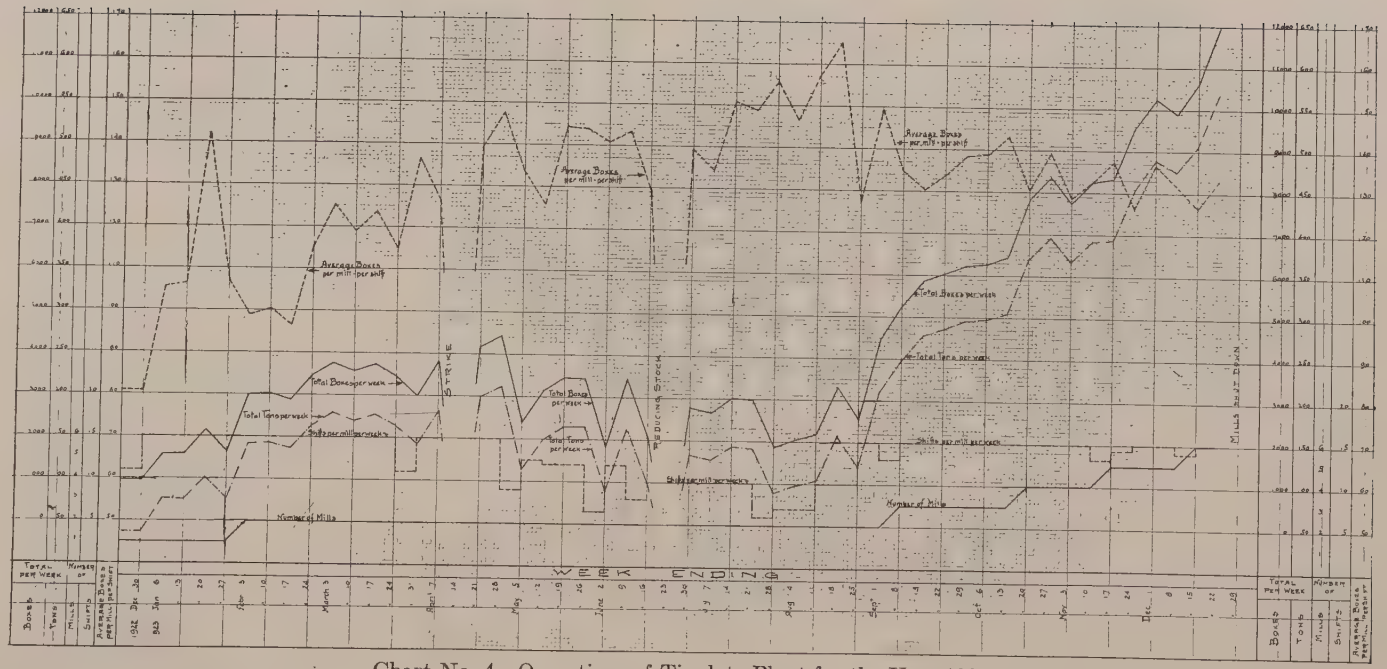

Chart No. 4—Operations of Tinplate Plant for the Year 1923.

TABLE A—OPERATIONS TO END OF YEAR, 1923

WEEK ENDING	NUMBER OF		TOTAL PRODUCTION PER WEEK		Average Boxes Per Mill Per Shift
	Mills	Shifts, Per Mill	Boxes	Tons	
1922—December 30	1	12	969	46.7	80.7
1923—January 6	1	15	1,583	75.7	105.5
13	1	15	1,595	75.5	106.3
20	1	15	2,130	101.0	142.0
27	1	15	1,610	76.3	107.3
February 3	2	15	2,984	141.2	99.4
10	2	15	3,012	143.0	100.4
17	2	15	2,887	137.4	96.2
24	2	15	3,454	164.3	115.1
March 3	2	15	3,756	178.9	125.2
10	2	15	3,567	170.0	118.9
17	2	15	3,714	177.1	123.8
24	2	15	3,449	164.5	114.9
31	2	11	3,001	141.3	136.4
April 7	2	15	3,792	180.8	126.4
14	Strike				
21	2	15	4,177	199.2	139.2
28	2	15	4,437	211.7	147.9
May 5	2	9	2,402	114.8	133.4
12	2	12.5	3,142	150.0	125.7
19	2	12	3,463	165.4	144.3
26	2	12	3,454	165.1	143.9
June 2	2	6.5	1,832	87.9	140.8
9	2	12	3,438	163.9	143.2
16	2	8	2,075	98.7	129.6
23	Reducing Stock				
30	2	10	2,784	132.5	139.2
July 7	2	10	2,684	127.8	134.2
14	2	10	3,016	143.8	150.8
21	2	10	2,976	142.0	148.8
28	2	6	1,871	88.5	155.9
August 4	2	7	2,053	97.0	146.6
11	2	7	2,192	103.6	156.5
18	2	10	3,302	156.9	165.1
25	2	10	2,547	120.5	127.3
September 1	2	15	4,483	212.0	149.4
8	3	13	5,256	248.6	134.7
15	3	15	5,853	277.4	130.1
22	3	15	6,028	285.1	133.9
29	3	15	6,223	294.9	138.2
October 6	3	15	6,246	296.6	138.8
13	3	15	6,443	304.7	143.1
20	4	15	7,822	370.0	130.3
27	4	15	8,367	395.7	139.4
November 3	4	15	7,727	366.8	128.7
10	4	15	9,550	454.5	132.6
17	5	13.2	8,248	392.5	137.4
24	5	14.4	8,322	393.6	126.1
December 1	5	15	10,245	488.1	136.6
8	5	15	9,889	475.4	131.8
15	6	14	10,630	505.3	126.5
22	6	15	11,961	567.5	132.9
29	Mills shut down				
Totals and averages...	2.6	13.3	226,641	10771.7	131.4

were most loyally supported by hearty co-operation from the heads of the various departments.

When it is considered that two mills were able to operate throughout the initial summer and maintain a production to about the average, and do this in spite of such extreme temperatures as existed, it was safe to assume that what was done in 1923 on two mills, could be done in succeeding years on six mills. The results of operations during the year 1924 up to the present time have proven this to be true.

In the early summer of 1923 there were nine consecutive weeks during which two mills operated continuously with an average maximum temperature in the shade for the working days constituting this period of 105.9° F., the highest being 112°. The average minimum temperature recorded outside during this same period was 84.5°. Also, during this same time the temperature of air to the men at the mills never exceeded 89° maximum in the middle of the afternoon.

Therefore, we repeat that without all of these special provisions, including the extreme size of buildings, it is safe to assume that there would probably have been three months during the year that the hot mills could not operate. The results show that the expenditure for all these features was warranted. We wish to point out in connection with this same fact that, were some of the same ideas carried out in the design of tinplate plants in our country, as well as in Wales, the result would be practically the same. In this country during the summer months there are always several days over different periods in many of the mills when the men can not stand up to the work required of them, or else they will not report for duty and the mills must be shut down and production therefore lost. These same mills properly designed and equipped could be kept in continuous operation with entire comfort to the men, and the tonnages could be increased on many days.

In other words, a modification of these same ideas properly applied to the design of a new plant would certainly increase production over a year at least ten per cent, and this increase in production, together with the additional comfort to the men when working, would more than pay for the interest on the extra investment. In South Wales, in the summer of 1923, there were two weeks during which practically all of the tin mills were idle on account of heat, and the majority of mills in that country are not comparable to the mills in the United States in regard to size of building, spacing of rolls and facilities for the comfort of the men when working.

THE CHAIRMAN (Mr. Charles M. Schwab): We will now adjourn for luncheon and the meeting will reconvene at 2 P. M. in the room at the eastern end of the corridor.

A recess was then taken until 2 P. M. Members reassembled in the East Ballroom at the appointed time, Mr. E. A. S. Clarke, Secretary of the Institute, in the chair.

THE CHAIRMAN (Mr. E. A. S. Clarke): Gentlemen, Mr. John A. Topping, of the Republic Iron & Steel Company, one of the vice-presidents of the Institute, was to preside over this meeting, but he has been detained temporarily and I have been asked to get the meeting under way.

The first paper this afternoon is a paper on The Manufacture of Slag Brick and Other Slag Products, by Mr. C. E. Ireland, of the Birmingham Slag Company, Birmingham, Ala. Mr. Ireland assures me he would rather speak to a small audience than a larger one, so we will let him begin and he will probably get over his bashfulness before the others come in.

THE MANUFACTURE OF SLAG BRICK AND OTHER SLAG PRODUCTS

C. E. Ireland

Vice-President, Birmingham Slag Company, Birmingham, Ala.

This paper treats of blast furnace slag, the development of its manufacture in the Birmingham, Alabama, district, and its uses and adaptability as an aggregate in concrete products.

When the furnaces in the Birmingham district started producing slag it was necessary to dispose of it as cheaply as possible, and to do this it was poured from tall pine pole trestles. This method gradually built up mountains of slag which necessitated steep grades for the slag trains to climb or the spreading out over acres of valuable land. No care was exercised in pouring the slag in these piles separate from other waste materials, such as flue dust, brick and other refuse from around the furnaces. During the reclaiming of slag from these piles, for marketing in a limited way, much of it was rejected by the consumer on account of the waste materials it contained. It was impossible for the excavating shovels to pick out the clean slag when poured in this manner. Most of this slag was marketed as railroad ballast, but even then the waste materials were objectionable, in that they held moisture and shortened the life of the cross ties.

In 1912, when crushed slag was first brought into use in this district as a concrete aggregate, sizing was difficult as the waste materials were hard to separate from the clean slag. Slag poured from trestles down steep embankments cooled quickly and in thin sheets, which made it difficult to obtain a "roughly cubical" product

especially desired for use as concrete aggregate or for road metal in macadam road construction.

To overcome the objectionable features of this method of preparing the slag for commercial use, the Steel Company, together with the Slag Company, worked out and put into use what is known as the modified pouring pit system. Under this system four pits, one thousand feet long, fifty feet wide and fifteen feet deep, are used. These pits are adjacent and require only two pouring tracks, thereby reducing trackage to a minimum. They are located near the furnaces and are permanent, inasmuch as they are constantly refilled when excavated by shovels of the Slag Company. These pits are filled with only clean slag, and as the slag is poured into these pits it puddles itself into thick layers and cools very slowly.

To scientifically prepare the puddled slag produced by the six blast furnaces of the Tennessee Coal, Iron and Railroad Company at Ensley, the Slag Company completed in 1917, a modern, electrically operated crushing and screening plant, located alongside the pouring pits described above. Its product, at the rate of 4,000 tons daily, is marketed throughout the six Southeastern States.

Upon being excavated by electric shovels the slag breaks into large, solid, cubical pieces, is loaded into trains of three, twenty-yard side-dump cars and transported over a third rail system to the crushing plant. The slag is dumped from these trains into a hopper over the crushers which are located below the ground level. It is fed to the crushers over a scalping screen which bypasses the small slag around the crushers directly into the skip loading hopper. Large pieces of iron, sometimes three feet in diameter, are caught going over the scalping screen and are removed by an electric crane for reloading to the furnaces.

Two eight-yard skips are used to elevate the slag from the crushers to the top of the screening plant, where it is fed onto the screens over magnetic rolls which catch all free iron and all slag that contains iron, dropping it

into a separate bin for loading into cars for reclaiming for the furnaces. In passing through the screens nine different sizes of slag are produced, ranging from four inches down to dust. These standard sizes are used in many types of construction; namely, concrete highways, bridges, reinforced buildings, water-bound and bituminous macadam, asphaltic concrete, sheet asphalt binder, and various patented types of pavement.

A special size, from six to twenty inches, is produced for the United States Government and used on the Mississippi River banks as rip-rap and for mattress beds on the floor of the river. During the past three years approximately 80,000 tons of this size have been used for this purpose.

Slag has been found ideal for highway construction on account of its toughness and natural bonding properties. It has also been used with much success in sewage filtration plants and in built-up roofs. Large quantities are used by the railroads for ballast, and during the past few years some of the railroads have found that a screened slag with the fines taken out makes a better ballast than the bank run slag and, even at a higher price, is more economical in the end.

After a period of years a rate structure for slag was built up and at the present time covers shipments to all points in the Southeastern States. During this time the use of slag was promoted as equal to gravel, granite and crushed stone when used as a concrete aggregate, and a long series of tests were carried out to prove this equality. Even then some engineers did not accept the results of these tests and many questions, such as the effect of the sulphur in the slag on reinforcing steel, were brought up and successfully thrashed out in favor of slag. As a result of this series of tests slag was found to produce a stronger concrete than stone, granite or gravel, due to its angularity forming a more perfect bond with the mortar. To-day this fact is accepted by most engineers and slag is favored by them on account of the dependable

quality and grading of the various sizes. The demand for blast furnace slag produced in this scientific manner has gradually increased each year and at the present time about sixty per cent. of the slag produced by the furnaces in this district is sold commercially. During the year 1923 over 1,000,000 tons were shipped by our Company alone, approximately 26,000 carloads.

In the manufacture of these various sizes of slag, about ten per cent. of the production will pass through the quarter-inch screens and is known as slag sand, having a gradation about the same as a good concrete sand. For a number of years there was only a small market for this size, necessitating storage in large stock piles which were gradually consuming all available storage space. To overcome this difficulty investigations were made to find a suitable use for this material. After a series of experiments it was found that this finely crushed material possessed a certain amount of cementing qualities, naturally suggesting the manufacture of concrete products. The demand for the various concrete products was investigated, and it was decided to manufacture concrete brick.

After visiting brick plants in various parts of the country and consulting operators as to the type of machinery, methods of curing, etc., a plant was designed and built with a capacity of thirty thousand brick per day and sufficient shed storage for a million face brick. The original plant used a batch mixer and hand tamping machine, but, because of the roughness of the slag, tamping was found difficult with these hand machines, and the mixer would only work at half capacity. As a result, a continuous mixer was installed and all machines fitted with power tampers which increased the capacity of the plant, each of the twelve machines having a capacity of two thousand face brick or seven thousand common brick per day. No material is handled by hand, bucket elevators being used to elevate both cement and slag to bins above the mixer. This material is fed to the mixer

by gravity, and the concrete in turn is distributed to the hoppers in the rear of the brick machines, which are in batteries of four, by belt conveyors. The concrete is drawn into hand hoppers by the operation of an undercut gate. Ten brick are made at each operation directly on a wooden pallet, and these pallets of brick are removed from the machines, placed in stacks eight high and are wheeled into steam curing room, one stack at a time, by a steel-framed buggy with pneumatic tires. The brick are steamed twenty-four hours, removed from the curing room on jack-lift trucks and stacked on the yards for curing until ready for shipment.

Great care is exercised in the selection of material for concrete brick: only Portland cement is used. The slag should be graded so as to obtain a maximum density without impairing the strength of the product, thereby getting a good hard brick with an ideal percentage of absorption. The slag is handled so as to prevent segregation of the material, which would cause alternate batches of coarse and fine slag to go into the mixer. To accomplish this a storage bin was built as an inverted section of a pyramid, and the material dumped into the bin in a conical pile. The material on leaving the bin will recombine and give a consistent gradation.

Mixing should be as thorough as operating conditions will allow. Although it is conceded that a batch mixer gives a better mixed concrete, the variation of the mix in a continuous mixer is so small that it does not vary the compressive strength of the brick to any serious extent. As a semi-dry mix is used, much care must be taken to see that all water possible goes into the concrete in order to get the maximum strength from the cement used. This mixer is automatic in proportioning the slag and cement, and a check is kept on this through the finished product, to be sure that the proper amount of cement is used per thousand brick.

In the actual making of the brick the draw-blade type machine has been found to be very satisfactory, in that

this machine is very simple, easily repaired and can be kept in positive alignment. Wooden pallets are placed on the body of the machine, and the blades are drawn forward and a header bar is clamped on the front of the blades to complete the mold. As before mentioned, concrete is drawn from the large hopper at the rear of the machine into the hand hopper by the operator. The material is pulled over the mold and tamping is done by automatic power tampers. These tampers have five feet, each of which tamps two brick, exerting a pressure of one hundred foot pounds at each stroke. Five series of strokes are used in each operation, giving a total pressure of five hundred foot pounds per brick. After the brick are tamped excess material is cut off with the hand hopper and the common brick are troweled to a smooth surface, removed from the machine and placed in stacks ready for conveying to the curing room.

Face brick are made by supplementing the operation used in the production of common brick. After the concrete is tamped in the mold and the surplus material struck off, a mineral coloring, in powdered form, is sprinkled over the surface and thoroughly worked in with a wooden float. Enough water is added to make the facing plastic. The brick are then troweled with a steel float and another coat of color applied, which is stippled with a rice root brush to make a rough texture, or made into a wire cut by drawing a steel-toothed comb across the face. The face brick are made in several different colors and can be furnished either wire cut or rough texture. Making the face and body of the brick in one operation produces a monolithic product impervious to water.

All brick are cured in steam rooms, using low pressure saturated steam. This steam enters the room through pipes laid in trenches in the center of the floor. A heat of 125° is maintained when common brick are being cured, and 90° when face brick are being cured. The brick are allowed to remain in the curing rooms for twenty-four hours, which is equivalent to about seven days' air cur-

ing and enables the brick to be stacked on the yard immediately after being removed from the curing room. In no case should the temperature go above 90° when face brick are being cured, as any heat above this will cause efflorescence and ruin the product entirely.

From the curing rooms the brick are hauled to the yard on jack-lift trucks, carrying four hundred brick at a load, and stacked in rows fifteen brick high, ten brick wide, leaving an air space of about four inches between rows to expedite setting. As the cementing qualities of the slag are depended upon for part of the ultimate strength of the brick, no water is added to them after being stored on the yard, because slag sets very slowly when kept wet. They are left on the yard to air cure for thirty days before shipping.

Because of the cementing qualities of the slag a much leaner mix can be used than in the production of a concrete brick using sand as the aggregate. It has been found that a one to seven mix by volume is sufficient to give a compressive strength of two thousand pounds per square inch. Even a leaner mix than this can be used if there is ample space available to allow the brick to cure for a greater length of time.

The finished product is a brick of unusual strength, which increases with age and bonds with the mortar, producing a semi-monolithic wall, and is used in every type of construction. A concrete brick is not an imitation of clay or shale brick, but is a brick obtained by a different method of manufacture and using different materials. Concrete brick are just as hard and water-proof as clay or shale brick. They bond readily with the mortar and will not break away from the mortar in the wall because of expansion. This is due to the fact that mortar and concrete brick are composed of ingredients so nearly alike that the coefficient of expansion is practically the same. Because of the fact that they are not burned, no deformities occur from uneven distribution of heat, as is the case with a clay or a shale brick, and a concrete brick

once made true remains true throughout. Although our brick are manufactured in the heart of one of the best clay and shale deposits in the South, and in the midst of coal fields, the demand for them has steadily increased since operations were started. The market price of concrete brick in the Birmingham district at the present time is $12.50 per thousand for common brick and from $22.50 to $33.50 per thousand for face brick. The market price of the concrete common brick is about the same as the market price of the clay common brick, but the price of the concrete face brick, in most instances, is lower than either that of the clay or the shale face brick.

THE CHAIRMAN (Mr. E. A. S. Clarke): Discussion of this paper will be given by Mr. P. J. Freeman, Chief Engineer, Tests and Specifications, Public Works Department, Allegheny County, Pittsburgh, Pa.

MR. FREEMAN: I have a few remarks to make largely from the point of view of one using the material and not of one producing it or selling it.

Discussion by P. J. FREEMAN

Chief Engineer of Tests and Specifications, Department of Public Works, Allegheny County, Pittsburgh, Pa.

The author of the paper has pointed out the several uses of blast furnace slag, especially as an aggregate in concrete construction and in concrete brick. It has been my privilege to have made a number of tests of various kinds of slag to determine their suitability for many purposes, the most important of which were for use as a concrete aggregate in mass concrete, concrete products and concrete brick.

In view of the fact that clay brick have been on the market through the ages, there is bound to be a very keen competition. It is my observation that companies starting in to produce concrete brick have failed to take this fact into consideration, and although the quality of their product may be entirely satisfactory for structural

purposes, they should study the effect of competition. This has been particularly true in the Pittsburgh district, where shale and clay brick have been successfully made and marketed for generations.

In so far as the steel companies are concerned regarding disposition of slag, it appears to the speaker that the total quantity of slag which could be disposed of in the production of brick is small in comparison with the amount of slag produced. On the other hand, the use of blast furnace hard slag in mass concrete has unlimited possibilities. The author of the paper stated that his company had shipped over 1,000,000 tons of hard slag in 1923 for roads, ballast and concrete, but, based on the maximum capacity of his brick plant, it seems doubtful if he could use more than 25,000 tons of slag per year in the manufacture of bricks.

In the Pittsburgh district, the use of blast furnace hard slag in concrete products, such as hollow building block, far exceeds its use in concrete brick, and the largest manufacturer of concrete building block has been successfully using hard slag for approximately nine years.

A considerable number of tests have been made to show the strength and wearing qualities of slag concrete. The speaker presented a paper before the American Concrete Institute, published in Vol. XIV, 1918, which gives the results of compression tests made on slags from nine different sources in comparison with gravel, limestone, granite and traprock.

A paper presented before the American Society for Testing Materials, published in Vol. 23, Part II, 1923, by Raymond Harsch of the United States Bureau of Public Roads gave the results of compression tests in comparison with abrasion tests of slag and other concretes. Mr. F. H. Jackson of the United States Bureau of Public Roads last June gave further data and results of wear-tests on the circular track used by the Bureau of Public Roads for that purpose, and this paper will be

published in the 1924 Proceedings of the American Society for Testing Materials.

Mr. C. L. McKenzie stated in his paper read before this Institute last year, that at least 40,000,000 cubic yards of concrete is placed annually in the territory within shipping distance of slag. However, only 1,750,000 cubic yards out of 40,000,000 cubic yards is blast furnace slag concrete. This would indicate the vast possibilities for the extension of the production of high quality blast furnace slag for use in concrete.

It seems doubtful if the increasing demand for coarse aggregates can be supplied from the diminishing sources of locally available natural material deposits. In some districts, the shortage of sand is becoming a serious problem and the producers are crushing gravel to make sand, thus reducing the supply of gravel available for coarse aggregates.

In view of this large possible expansion in the use of slag as a coarse aggregate, as well as for other purposes which require large quantities of such material, it seems to me that very serious consideration should be given, in furnace operation, to the use of such flux stone as will produce slag of a quality thoroughly reliable and dependable for concrete aggregate.

The Chairman (Mr. E. A. S. Clarke): There are two more papers on the program for this afternoon's session, both of which are on the subject of Iron and Steel Scrap. The first paper, by Mr. W. Vernon Phillips, of the Perry-Buxton-Doane Company, of Philadelphia, Pa., is rather more on the commercial side, and the second paper, by Mr. E. J. Lowry, of Hickman, Williams & Company of Chicago, Ill, tends a little more toward the metallurgical side of the subject, if such a term may properly be applied.

First I am going to ask Mr. Phillips to step up and read his paper; but before he does it I want to say that Mr. Phillips was associated during the war with many

of the Committees of the Iron and Steel Institute as Chairman of the Sub-Committee on Scrap, handling a very difficult subject in a very successful and skillful manner; and I say that, not only to show that he is an authority in the matter, but to show that he is a man of very great experience on the subject. (Applause.)

IRON AND STEEL SCRAP

W. Vernon Phillips

Perry-Buxton-Doane Company, Philadelphia, Pa.

One of the purposes of the meetings of the American Iron and Steel Institute is to exchange information, impart knowledge and otherwise improve conditions within the industry, so that while an interesting address could easily be made on the subject of iron and steel scrap, an actually profitable and instructive paper on this subject meets with many serious difficulties. I can only hope that the suggestions put forth may be of help to the buyer, to the seller and, quite important, to the open-hearth superintendent.

In order that we may not wander too far afield, my remarks will pertain principally to steel scrap for the basic open-hearth, which probably represents 80 to 90% of the iron and steel scrap consumed today. It is not so long ago that the major portion of all ferrous scrap was used by rolling mills, either for direct rolling, piling, shingling, busheling or puddling. During the last generation a two-fold change has taken place, due to the greatly reduced operation of the rolling mill, and the expanding use and wider practice in the open-hearth. The scrap dealer and producer has had to gradually change his method of preparation, and study the needs and possibilities of the open-hearth, while the steel mill has had to study the problem of using scrap in a greater variety and of more liberal specification. The result today is that during this period of readjustment the steel mill is constantly complaining that the dealer is failing to ship what

he sold, and the dealer is complaining even more bitterly that the mill is unreasonable and inconsistent.

During periods when the demand is normal, the mill, while ordering a strictly No. 1 specification, accepts an average class of steel scrap; when the demand increases they become more liberal in their inspection, as they are in need of the material; but the moment the supply meets the demand, the mill falls back on its strict specification, and requires a grade of scrap which the dealer not only cannot supply, but also has not during normal times been expected to supply. This is the crux of the whole situation.

The Purchasing Agent's Association have endeavored, in conjunction with the Department of Commerce, to correct this situation, by drawing up new specifications, even more severe than the old ones, forgetting or not knowing that the root of the trouble is in the strictness of the present specification.

The truth of the matter is there is not sufficient high grade scrap to meet the needs of the mills when they are running normally. When operations fall off and become subnormal, they secure an ample supply of good scrap; but when demand exceeds normal (and by normal we mean 60%), they must accept a proportion of poorer scrap. Thus we have the paradoxical condition of "the higher the price, the poorer the scrap."

A possible cure for this condition would be continuous buying of scrap by the mills, thus reducing the wide fluctuation in prices, which is costly to the mills and of no benefit to the dealers. This partial elimination of price fluctuation would tend to stabilize the grade of scrap, as the dealer will know what is normally acceptable, instead of having to ship his scrap to suit the market, forcing him to exercise great care when shipping on the dull markets, and carrying his poor grades until a strong demand sets in. This may not sound reasonable and is perhaps not feasible but the fact remains that price variations are greater in scrap than in any other of the

steel commodities, averaging about 35% annually, over a period of 30 years. Actual figures show that over a period of twenty years prior to the war, the yearly average variation in the price of heavy steel melting scrap represented $4.67, while since the war (eliminating the war years) the average variation has been $7.25. The average pre-war price of scrap was $14.00, the post-war average, $17.85. This is based on average monthly quotations, and does not represent the average selling price which would be much higher, as the big tonnages are sold on the high markets when the demand is great, while comparatively little material is sold at the low points.

It is useless for the mills to say that they will only take the highest grades, and will not take the inferior grades.

The dealer cannot discriminate when he buys; he must take the entire locomotive; he cannot buy the choice part of a ship, of a building, or the acceptable parts of a freight car. What is he going to do with the portion that runs slightly under ¼″ thick? It is all acceptable enough when the mills want it, but if a few pieces of steel on a car run under specification on a falling market, the entire car is rejected. The shipper is immediately condemned and told that, since they have every reason to believe that if bad material appears on the top of the car, a lot more of this light, mean, miserable stuff will surely be found underneath; and in order to warrant them taking the risk of unloading they must have a reduction of $1, $2 or $3 a ton.

The instance is to some extent exaggerated and of course is not general in its application. There are many mills who pursue a reasonable course, either buying a high grade of scrap and paying a premium for it, or buying on the standard specification and taking in all cars on their merits, using a fair scale of reductions from the contract price, regardless of market conditions. Also this condition is not confined to heavy melting steel, the

same conditions applying to low phosphorus scrap, blast furnace and rolling mill scrap, but to a lesser extent. Nor is the fault by any means to be laid entirely at the door of the consuming mills. Many dealers deliberately doctor or improve the appearance of their cars, and in many instances brokers who are caught with bad orders on a rising market will knowingly buy inferior material in an endeavor to cut down their losses, but neither of these expedients profit either of them in the end.

As a rule, the dealer tries hard to ship what he has sold. He is punished so severely when he fails to do this, that there is little incentive to try to get by with inferior material.

The dealer was formerly able to deliver steel scrap to Pittsburgh at $14 (the average price before the war) and make a profit. Today the high cost of transportation and labor have increased the cost to $19.25, based on buying the material at the same price and using an average outside point for freight rates. Thus a $19 market today is not nearly as good as $14 was then.

While scrap has an intrinsic value based on its metallic content when compared to pig iron, it is still the sole creature of supply and demand. Were it not for the dealer's yards and purchases by operators, it would cease to have any value when mills are not operating; and while blast furnaces may close down, scrap continues to be produced, and if too far from a dealer's yard, must lie dormant until demand lifts the price to a point which admits of its moving toward the nearest point of consumption. As demand improves, the circle widens; when operations are very slack only the scrap in the immediate vicinity of the mill is purchased, then as demand increases the freight rates come into play, and from that point on, it becomes almost entirely a question of freight, until Pittsburgh mills will reach out to Canada, to far Southern points and finally abroad, until the incoming flood of scrap from the far corners of the earth satisfies the greedy mouth of the open-hearth. The moment this be-

comes apparent, prices go off and the circle begins to contract.

In addition to this geographical condition, the speculative element enters; producers, dealers, brokers and operators who normally sell thirty days supply ahead go onto a hand-to-mouth basis as the market advances until the moment arrives when prices show signs of breaking, then large tonnages are offered for sale from all quarters. I was profoundly impressed when the Armistice was signed. The day before, we were getting only the scrap being shipped day by day. The price was fixed at $30 and there was no incentive for anyone to sell more than they had ready to load; besides, with the apparent shortage, there was always the possibility of an advance, so no one felt the necessity of selling short. But on the day after the Armistice there was one month's supply, or a million tons of scrap, for sale. Mind, there was no more scrap in the country than on the day before; but there was every reason to look for a decline in price, and everyone wanted to sell their prospective production for thirty days ahead.

As a business, scrap reverses all normal merchandising, in that the competition is to buy, not to sell. The larger operators or brokers (as they are erroneously called) maintain large organizations with branch offices, and their buyers spread over large areas, while one or two men can do all the selling, the sales being made in thousands of tons whereas the purchases are in carloads, or at most in hundreds of tons.

The so-called broker is really a merchant, banker and adviser. He must be an able judge of conditions, taking great risks in selling large tonnages which must subsequently be bought. He must have large means, as the small dealer needs cash almost before he makes his shipments, and must trust to the knowledge of the broker, who, to be successful, should be endowed with a wide knowledge of the steel business, of the intimate needs of each consumer, and while he may not need to be a metal-

lurgist, must at least have a superficial knowledge of metallurgy.

Scrap used to be scrap, but woe to the dealer who would now ship .80 chrome on a nickel steel order, or .05 sulphur on a low phosphorus steel order. He must keep out manganese steel, since the mill magnet will not lift it, and he thanks God that vanadium uses itself up, as it has no evident way of showing itself. He must not ship street car rails, as the cast iron welds may be very high in sulphur, and if there are no welds, they are sure to contain a lot of concrete or cement, and yet they must be melted by someone. He must not ship bushy turnings, though the blast furnaces are constantly calling for more turnings, meanwhile the machine shops are installing more automatic machines daily, running at high speeds and turning out more bushy turnings.

No, scrap is no longer scrap, it is fast becoming a manufacture. A modern yard capable of preparing scrap to meet mill requirements represents outlays running into hundreds of thousands of dollars, starting with trackage, locomotives, overhead and locomotive cranes, derricks, magnets, shears, drops, compressing machines, machine shops, and last but not least, torching outfits with their generators and equipment.

Unfortunately all this equipment has not reduced the cost of preparing scrap, it has actually increased it, but it has taken a burden off the mills, since it prepares the scrap in exactly the manner required by them. Unfortunately these large yards represent but a small part of the tonnage shipped to the mills, the greater portion coming from the hundreds of small yards, located to take the scrap in their localities, and giving it only such preparation as is within their means. The small yards are increasing in number, while the large yards find it increasingly difficult, owing to the high freights, which make it necessary to prepare the scrap for mill use at the point nearest to its production, it being no longer possible to ship this scrap to large central yards. Consequently the

large yards are operated principally by the so-called brokers who use them for back logs in making heavy sales and for storage yards when the industry runs into a period of real depression. It does not pay to store unless an advance of at least $4.00 can be anticipated, and it usually means one year with the cost of carrying, unloading, loading and the freight out.

The scrap market is not unlike the stock market in that it anticipates improvement and depression sometimes by several months. It is a common occurrence to see scrap prices rising while finished steel is still falling, but it invariably predicts an improvement in demand, which eventually means higher prices for finished steel. Likewise scrap will often begin to fall before finished material has stopped advancing. There are times when this is not borne out, and the rise in scrap proves to be a false start, but it is usually a very good barometer.

The larger dealers or operators likewise buy long and sell short, so that when the market turns weak and the mills discontinue buying, the brokers with orders give an outlet to the railroads and producers. When the market reaches a point where the mills will not even accept shipments, as always happens during periods of depression, the dealers purchase to store for the long pull.

Some may rightly say that my remarks apply almost entirely to dealers, and not to the tonnage which is sold directly to the mills by railroads and producers, but after all it is the dealer's scrap that makes the market. It is principally the dealer or broker that buys from the producer and the railroad, it is the dealer that is most in need of education, and it is the dealer whom the mill should try to help rather than antagonize. Some mills look upon them as a barely necessary evil, and it is time for the mills to realize that they cannot profitably do without the dealer, they cannot possibly go to the far corners, collect and prepare the scrap for their own or some other mills' use, and that the time has come for them to co-operate with him, to help and guide him, in-

stead of everlastingly damning him. He is here to stay, and is anxious to do his part. During the war he played his part, and I can vouch for the fact that he played it at least as unselfishly and fairly as any other industry in the country.

The Chairman (Mr. E. A. S. Clarke): I am going to ask Mr. E. J. Lowry, of Hickman, Williams & Company, Chicago, Ill., to deliver his paper on Iron and Steel Scrap, which treats the subject from a different angle, and after that we will have the discussions, so that those discussions can touch on both of the papers.

IRON AND STEEL SCRAP

E. J. Lowry

Metallurgist, Hickman, Williams & Company, Chicago, Ill.

The increasing use of scrap in the iron and steel industry promotes the conservation of our natural resources. Incidentally, its utilization gives a greater production per unit of time at less cost, in itself a worthwhile consideration, but it is as a conserving agency that scrap lays claim to a leading place in our national economy. Every ton of scrap consumed in the manufacture of steel saves for posterity a definite amount of raw materials, which will remain stored in nature's warehouse as our legacy to future generations. It is the important duty of the producers to preserve their raw materials in order to assure the permanence of their position in the World's iron and steel business. The reclamation of used materials, therefore, assumes a position of heretofore unmeasured importance in this industry.

The tonnage of iron and steel manufactured yearly and the production of scrap move in a definite relation. The accumulation of scrap is in relative proportion to the ingots and pig iron produced. It is therefore essential that the scrap heap be consumed in order to forward the spirit of conservation. Yet, the consumption of scrap must be based upon the "going" melting capacity of the country and limited only by the varying ideas in the minds of the melters in regard to scrap mixtures.

It is obvious that a cycle of motion could be set up, weaving the two industries together. Thus, finished steel is sent out through its various avenues to fabricators who, in their turn, send out their finished products to

consuming areas. There, these goods become at the end of their service probable candidates for the scrap heap. The general direction of the flow of scrap is counterwise to the travel of finished steel. Steel is most heavily produced in large centers in the East and Middle West, while scrap makes its appearance all over the country. Brought together in hundreds of centers, it is shipped in radial lines, governed by market conditions, to consuming points.

This accumulated scrap is of all descriptions, weights and analyses. But without regard for metallurgical considerations, it is shipped to the consumer upon specifications of untrue value. Grades, such as heavy melting, busheling, etc., are the governors and the dimensions are usually specified as "charging box," or "shoveling" size, etc. Such descriptions do not fit the requirements of the present time and perhaps form an impediment to the growth of the use of scrap in the manufacture of steel. Today, scrap is looked upon in the light of its name, whereas it should be evaluated on the basis of its ability to return economy and perfection to the consumer. For the legitimate future of the scrap business, it is essential that metallurgical adaptions be set forth as a requisite to progress in the right direction.

The interest in scrap iron and steel is not wholly confined to the foregoing. It covers also the question of statistics and the internal mechanism of the trading in this material. The scrap business has grown from nothing to a position comparable to any of the other industries producing basic raw materials. Through this growth practices were formed which affect the buyer and seller alike. These practices, having grown empirically, embrace both good and bad business ethics. The bad possibly offsets the good and holds the scrap business below the level to which it deserves to rise.

It is for the purpose of aiding in the enlightenment of the consumer, producer and seller of scrap iron and steel in the foregoing issues that this paper is written.

Metallurgical Considerations

The manufacture of steel is of a complex nature. Its production entails both physical and chemical factors. Many processes have been evolved to produce steel under different modes and with different materials, the most universal of which is the basic open-hearth process. Due to limitations of space, the discussion will be confined mainly to this type of process, and to considerations which affect the consumption of scrap.

Some of the governing factors in the use of scrap in the open-hearth are (1) the grade of steel to be made, (2) the chemical elements required in the charge, (3) the slag volume, (4) the quality of the scrap, (5) the effect on the life of the furnace, (6) the weight per cubic foot of scrap in comparison to its over-all dimensions and (7) the ultimate cost of the metal in the ingots.

1.—The open-hearth had its inception in the acid process. This was essentially a practice which involved the use of low phosphorus pig iron and low phosphorus scrap. As the demand for steel grew, it became apparent that some way must be worked out to use the plentiful high phosphorus ores of our country. This problem was solved by the development of the basic process for steel making. It has long been contended that the acid process gives superior steel to the basic operation. Inasmuch as the acid process carried high percentages of scrap, the question naturally arises, "what effect does scrap have on the quality of steel made from its mixture?" It is the general practice in the United States to charge some scrap in all mixtures. A better quality of steel can be made with the maximum scrap charge than with higher percentages of iron and ore, unless these materials are of an exceptional nature. It might be said that any good quality steel may be made from any good quality scrap when the latter is used in proper percentage. As an instance, a high carbon steel heat may be nicely "worked" with an average of 60% pig iron or hot metal

and 40% scrap. Whereas, in a low carbon heat, the proportions might easily be reversed. It is possible to use any grade of scrap in any percentage in the manufacture of steel, provided the requisite chemical elements, known as metalloids, are present and the heat is worked properly. The economic factors which must be taken into consideration in such scrap heats are production, time and cost. Therefore, the limiting factor in the use of scrap is perhaps not so much the effect upon the quality of the finished steel as the combination of cost and chemistry.

2.—The principal metalloids which play an important part in the manufacture of steel are carbon, silicon, manganese, phosphorus and sulphur. These elements are contained, within limits, in basic pig iron. The amounts present are considerably in excess of those required for steel. Therefore, the open-hearth furnace is used as a medium by which they may be reduced.

Steel making would become relatively simple if pig irons could be made which would contain the requisite amounts of each of these elements. In fact, we would make little pig iron under such circumstances. It would be all steel direct from ore. But the iron ores of the country and our method of reducing them to iron in the blast furnace will not permit the consummation of such a panacea. Consequently, the problem which confronts us is an economical way to bring these elements to the percentages required for the various grades of steel in use.

In arriving at the solution of our problem, we must remember that the various grades of steel required have definitive amounts of these elements contained in them. In obtaining these percentages in the finished steel, it is necessary for the heats to begin with relatively higher percentages of each of these elements. It is essential that carbon, manganese and silicon be present in certain definite amounts in order to make the "heat" a workable one. In other words, the melting and refining reactions of the open-hearth, being essentially oxidizing, require

the presence of these elements in order to protect the iron itself from oxidation during its conversion into steel.

These elements may be contained in the pig iron, or they may be built up in the charge to the required percentage by the use of carbonaceous material, ferro-alloys, etc. But they must of necessity be there.

To convert pig iron to steel requires the transfer of the metalloids from the iron charge to the slag. The oxidizing action of the furnace in the case of high iron heats must be increased by the use of limestone and iron ore (iron oxide) so that the metalloids (with the exception of carbon) may revert to slag. The danger encountered in this process is that an excess of iron ore will produce an over-oxidized, soft melting heat, with heavy losses of iron in the slag.

The relation of pig metal to scrap is dependent upon the constitution of the former. Where the carbon, silicon and manganese are high, a greater proportion of scrap may be used. In case these elements are low in the pig metal, then either they must be built up with outside agents, or the scrap percentage decreased. Perhaps the element manganese best illustrates this problem. It is said that a perfect working heat at the finish will require 0.30 per cent residual manganese in the bath and 12.00 per cent in the slag. Any wide variation of these percentages affects the quality of the steel produced. Again, if the carbon is too low, then a recarburizer of some sort becomes necessary to build it back to meet the specifications required of the steel. And so it goes for each of the elements. They have their specified duty to perform in the making of steel to meet trade requirements, which include both chemical and physical specifications.

Scrap contains the same metalloids as basic pig iron, only in lower percentages. Therefore, scrap may be used to dilute these chemical elements to the required amounts for establishing quick working and good quality steels. The one element which is of an uncertain nature is sulphur. This element may have been low in the original

steel produced but, due to the type of work to which this steel may have been applied, the sulphur may have increased. For instance, this element is increased in steels which have been surfaced with sulphurous materials, such as boiler pipes with lime and sulphate incrustations, automobile tire rims with parts of rubber tires adhering, etc.

Little does the shipper of scrap realize the havoc he plays with the steel maker when he sandwiches these materials in with what is called the heavy melting steel grade. True, inspection by the receivers of cars of scrap should catch and eliminate this harmful material, but there are many instances, where, through neglect or carelessness, such scrap enters the furnaces.

The reduction of unsuspected high sulphur material may extend the time of a furnace heat to as long as fourteen hours and even then yield a steel which will be rejected. It is impossible here to recount the details of working high sulphur heats. Suffice it to say, that the introduction of sulphurous materials increases the cost of production in progressive proportion to the amount of sulphur added to the charge.

Next, in the order of their harmful effects on the steel produced, come the rarer elements, such as chromium, copper, nickel and other alloys. When one considers this much mooted question, the first impulse is to say, "There isn't enough produced to hurt anyone." But, refer to the tonnages of alloy steels produced, and then ponder upon their effects on the cost of steel production. The alloy steels produced in the years 1909 to 1917, inclusive, amounted to approximately 7,400,000 tons, while from 1918 to 1923, inclusive, 9,500,000 tons were made. It is quite probable that a considerable percentage of the 7,400,000 tons is now appearing as scrap, while small accretions of the 1918-23 tonnage help to swell this amount. The fact that the production of alloy steel has increased from 0.75 per cent of the ingot production in 1909 to 4.70 per cent in 1923 is significant of the ever-

increasing demand for such steel. This will have its ultimate influence upon the scrap produced in years to come.

But what difference will it make if chromium, copper or nickel is present in the scrap? It is difficult to estimate the effects from such alloy inclusions in scrap. Chromium, under some conditions, is readily oxidized from the molten metal in the furnace, leaving the finished product unharmed. But chromium causes a thick, sticky slag which is hard to work. Hence, even though the steel is not affected, the cost of working the heat is increased. Suppose some chromium remains in the steel, what then? Some sheet steel manufacturers recently discovered that pits were appearing on their finished product. The source of the trouble was traced to chromium in the scrap. This element gave to the steel the property of resisting acid. Consequently, when the sheets were pickled, some scale adhered to them, causing pits to appear after the finishing rolls had performed their work. This is but one illustration of the effect of chromium in scrap.

Copper cannot be eliminated from steel. Once it is introduced to make acid-resisting steel, it remains. It cannot be removed from the scrap, even upon re-melting. Copper is known to produce red-short steel, unless the steel is properly handled. Everyone will readily admit that such steel will cause "defectives" which increase the cost of manufacture.

Nickel is another element which remains unresponsive to the refining reactions of the open-hearth. Perhaps its only bad influence is to give a poor finishing surface to steels containing any appreciable percentage.

These few illustrations have not been cited for the purpose of suggesting that scrap be handled on an analytical basis. To take such a position would be deemed ridiculous. The illustrations are intended, however, to show the difficulties experienced in melting which are traceable to the material a dealer has sold as scrap. They also may tend to impress the dealer with the

importance of exercising greater care in purchasing scrap to fill his orders.

It is recognized that there are classifications covering some grades of alloy scrap, but they are inadequate for general application. When scrap contains any of the precious elements, it should be diverted to the proper avenues of consumption. In other words, scrap is not just scrap. It is a by-product of the several manufacturing industries and of the country as a whole. As such it should be handled as in a distilling process: properly fractionated and sent to its appropriate reservoir.

3.—In the conversion into steel of metal charges in the open-hearth, a slag is required to absorb the oxidized metalloids from the bath and also to protect the molten metal. The higher the percentage of pig metal in these charges, the greater must be the slag volume in order to hold the oxidized metalloids.

The principal slag-forming agent is limestone. In the case of a high percentage of pig metal, an excess of lime must be used in building up the slag volume to a point where it will hold this increased amount of oxidized elements. Any amount of lime over the minimum (that required for a high percentage scrap-heat) used in the production of steel proves an absolute loss in both material and heat. Such losses add to the inefficiency of the furnace and thereby increase production cost. From this standpoint, therefore, scrap is an aid in the production of steel.

4.—The quality of scrap undoubtedly influences its economic utilization. Light weight scrap, such as loose sheet steel clippings, is bulky and fills the furnace to a point where the flame impinges directly upon it, causing heavy oxidation to take place with a resulting high melting loss. Such conditions convert the scrap to oxides (FeO and Fe_2O_3) which act the same as iron ore. The relative cost of iron ore as compared with this furnace-made scrap-ore emphasizes the waste resulting from such

a practice. This loss could be prevented if the sheet scrap were compressed.

Scrap which is heavily rusted or burnt is not an economical material for use in melting practices. Here scrap-ore is produced by the elements of the atmosphere, or by fire. The loss caused by this corrosion may be computed by taking the weight of the rust and charging it with the cost of iron ore. Then, the difference between the original cost of this amount of scrap and the iron ore cost will represent the loss experienced by using such material.

The use of dirty scrap adds to the cost of steel manufacture. In the first place, the dirt or sand is sometimes paid for at the price of the scrap purchased. Even if the scrap has been given a differential to take care of the amount of dirt appearing, the cost of operating with dirty scrap is greater than with clean scrap. This is due to the use of an increased amount of limestone required to flux or absorb the impurities, to the resultant prolonging of the heat and to the reduction in the efficiency of the furnace.

Galvanized or tinned scrap is another source of trouble to the steel maker. The weight of the coatings on such scrap is a total loss to him. Further, the zinc and lead in a galvanized coating create trouble in the furnace. The zinc turns to an oxide and finds its way over to the checkers, where it clogs the passages and reduces the efficiency of the pre-heaters. The lead sometimes acts in the same way, but more often it separates and settles to the furnace bottom, where it creeps between the bricks and opens them up. Such action shortens the life of the furnace and increases costs.

In the case of tinned scrap, the tin enters the bath and forms a compound with the iron affecting the physical qualities of the finished product. It is, therefore, something from which steel makers wish to escape.

Pieces of galvanized or tinned scrap find their way into good grades of melting steel. Whether it is inten-

tional or not, such mixtures of scrap tend to reduce the desire of the melter to increase his scrap consumption.

Annealing pots are another class of material contributing to the prejudice against the use of scrap in the open-hearth. An interesting experiment was performed on this grade of scrap to show the loss encountered in preparation. Two cars of annealing pots were shipped to a yard and broken in pieces 14″x20″ in size. The weights of the cars leaving the yard loaded with the broken pot scrap showed a loss of 16.1%. This loss was due to the breaking off of scale, which forms on the pots as a result of their constant reheating. This scale is no more than iron ore in the form of iron oxide and as such it should be judged. When they are free from scale, annealing pots constitute good melting scrap.

The two cars mentioned above were shipped to a mill for experimental purposes. Samples were taken and the analyses were as follows:

Sample Number	Carbon	Manganese	Phosphorus	Sulphur	Silicon
1	.04	.50	.150	.064	.93
2	.04	.50	.146	.088	.95
3	.06	.25	.156	.154	1.05
4	.39	.36	.154	.115	1.00
5	2.64	.20	.156	.097	.90

This scrap had a coating of scale (oxides of iron, about ⅛ to ¼ inch thick on one side), which was also sampled and analyzed as follows:

Iron	72.70
Phosphorus	.170
Manganese	.41
Silica	2.24
Alumina	.09
Lime	None
Magnesia	None
Sulphur	.082

The large amount of scale (approximately 0.10% of the total weight of material) made this scrap a poor grade for open-hearth use. The scale mentioned above as lost in preparation is in addition to the last approximated amount.

It is obvious from the foregoing that difficulty would be experienced from sulphur additions introduced by

both the annealing pots and the scale. Therefore, the wrong done by the inclusion of such scrap in a melting steel order is at least two-fold. The above analyses are from an exceptionally good grade of pots. There are instances where the sulphur runs to twice the amount shown.

Large percentages of heavily painted scrap prove objectionable in the open-hearth furnace. The paint carries considerable amounts of zinc which, when oxidized, becomes associated with the brick and fluxes the silica contained therein.

5.—The quality of the scrap used in open-hearth practice has an important bearing on the life of the furnace lining. Where the scrap is light in weight and bulky in volume, it fills the furnace high above the bottom. This causes the heating flame to impinge upon it directly. The flame is then deflected to the roof and side walls, causing a subsequent fusing and burning away of the bricks. By way of contrast, heavy compact scrap requires but a small volume of the furnace chamber. Consequently, the travel of flame is not deflected, the loss in brick work is lessened and the melting time decreased.

Siliceous material adhering to scrap affects the life of the furnace, because when it is not taken care of with limestone, it readily attacks the bottoms and banks, creating an excessive loss in refractories and production. Where sand is present in great proportion, it has been known to flux the basic lining of a furnace in one heat, causing great loss.

Limestone may be added to offset the amount of sand and dirt introduced into the furnace by the scrap, but this mode of operation proves unsatisfactory from the standpoint of furnace efficiency. Obviously, the element of risk in open-hearth practice is accentuated through the introduction of scrap of this character.

6.—The factor of greatest importance in the economical use of scrap in the open-hearth is "the weight per cubic foot of scrap in comparison to its over-all dimen-

sions." Everyone has thought of it, but it has become routine and neglected.

If we take concrete examples, the magnitude of this question becomes clear. Therefore, the following illustrations are given:—

1.—Charging box size, 74½"x20"x25".

Weight of one charging car loaded with heavy weight scrap.....=16,000 lbs.
Weight of one charging car loaded with medium weight scrap.....= 7,500 lbs.
Weight of one charging car loaded with light weight scrap= 3,000 lbs.
Charging car in all cases contains four boxes.

2.—Charging box size, 76¾"x22½"x28½".

Weight of one charging car loaded with heavy weight scrap.....=21,800 lbs.
Weight of one charging car loaded with medium weight scrap.....= 9,200 lbs.
Weight of one charging car loaded with light weight scrap= 4,760 lbs.
Charging car in all cases contains four boxes.

Heavy scrap included bloom butts, miscellaneous rails and similar scrap. Medium scrap included miscellaneous scrap, automobile and railroad scrap. Light scrap included sheet scrap.

As an example of the effect of the weight of scrap on the cost of a steel heat, the above figures in (1) were taken and the amount of cars, labor and time required by each grade in a 200,000 pound heat using 40% scrap, were estimated as follows:—

	Heavy Weight	Medium Weight	Light Weight
Number of cars	5	10–11	26–27
Number of loading men	3	4	5
Time of charging, minutes	12 to 14	25 to 28	78 to 81

The above figures were computed on average times of charging for each grade, including hold-ups, and the average tonnage handled per man on each grade.

To further illustrate the tonnage of various grades of scrap, capable of being handled by charging boxes of various sizes, the following is given:—

Kind of Scrap	Weights in Pounds		
Size of Box	24″x 18″x 66″	24″x 18″x 72″	24″x 21″x 60″
Bloom butts	3,200	3,500	2,750
Bundles (hydraulic)	1,800	2,500	1,875
	1,850	2,525	1,880
Loose sheet	950	1,000	800
	1,000	1,250	1,100
Plate	2,000	2,500	2,000
Pig iron	3,000	3,750	3,450
	3,750		
Pit	950	1,000	800
	1,300	1,225	1,025
Rails	2,050	2,500	1,875
		1,625	1,200
Shoveling	4,475	5,250	4,125
Slabs	1,700	2,000	1,500
	4,500	5,000	4,000
Structural, heavy	2,300	2,500	2,100
Structural, light	1,400	1,500	1,300
Turnings	1,300	1,500	1,200
		1,750	1,300

The weights shown above represent the average work at four different steel works. To show the variation which might enter such figures and the reason for any spread in tonnage being given under some of the items, it is necessary to compare hand loading or spotting of scrap in the boxes with magnet loading.

In loading a four-box charging car by the magnet, 14,500 lb. of bloom butts made an average carload, whereas, when the material was "spotted" by the crane and the use of a chain, 21,000 lb. became the average carload. The result of the experiment with these two methods of handling scrap shows the effect of the compactness of the material on the charging time of an open-hearth furnace. It would require approximately 14 cars, loaded by magnet, to charge a 200,000-lb. heat, while only 10 cars of the weight of the hand "spotted" material would be required. This is assuming that the heat was composed entirely of cold material. Where percentages of hot metal are used, the computation may be based upon the tonnage of cold metal entering the furnace.

Another point of interest is the saving in the handling time attributable to the manner in which the material is prepared. As an instance, car sides cut 18″x5′ and under and loaded into a four-box charging car gave an average weight of 4100 lb. A stocker was able to handle between 10 and 12 tons per day of this prepared scrap. The same stocker handled 15 to 17 tons per day of car sides cut 12″x12″ in size and the average weight of a four-box charging car was 6200 lb.

Sheet clippings offer a most striking illustration of the importance of scrap preparation. Loose sheet clippings give an average weight varying between 3200 and 5000 lb. for a four-box charging car depending upon the size of the boxes. This same material, bundled under pressure, gives an average weight of 5800 and 10,000 lb. for a four-box charging car with boxes 24″x18″x72″. The difference between the first and last groups shown is caused by the compactness of a bundle. At the most a stocker can handle from 10 to 12 tons of loose sheet per day, as compared with 13 to 15 tons of baled sheet (6800 lb. per car), and 16 to 20 tons of well compressed sheet (10,000 lb. per car).

The weight per cubic foot of the baled sheet (20″x22″x18″) is 43.3 lb., while that of the well compressed sheet (7¼″x8″x28″) is 210.1 lb. per cubic foot of displacement. The baled sheet is clumsy to handle. Frequently the bale breaks open, causing the stocker to handle the mass in the same way as loose sheet. As against this, compressed sheet is easily handled and forms a melting stock equal to bloom butts.

As a matter of interest, a grade of scrap known as loose steel turnings, which is considered undesirable scrap for the open-hearth, may be prepared to form excellent melting stock. Several large producers of this grade are briquetting turnings under pressure of 50,000 lb. per sq. in. and producing a steel of at least 60 per cent density. Such briquettes have a weight of over 275 lb.

to the cubic foot and therefore are practically equal to bloom butts.

Thus, those grades which appeared to be uneconomical scrap, from the figures shown in the foregoing tables, may be prepared so as to equal some of the best grades of waste material.

As a matter of comparison of various sizes of bundles, the following table is given:—

Dimensions, Inches	Weight, Pounds	Weight per Cubic Foot, Pounds
10 x 10 x 28	330	206.2
8 x 10 x 20	100	111.1
14 x 18 x 18	240	92.3
12 x 12 x 18	125	83.3
8 x 10 x 14	100	166.6

The pressure under which the compression is done greatly affects the weight per cubic foot of the bundle.

The foregoing table indicates the reason why it is now suggested that scrap specifications be made to include "the weight per cubic foot in comparison with the over-all dimensions." To accept such an addition to the scrap specifications means a tearing down of the present heavy melting grade structure. This will create more grades, but in the end economy will accrue to all. At present, excellent grades are being mixed with poorer grades and applied on orders. This makes all the grades in any one shipment take the same price with the result that waste of labor and time occurs in the steel works. On the other hand, the dealer loses the right to the advantageous prices which might be had for good melting stock. In other words, the present existing specifications seem to prove the old adage "Waste for one means waste for the other." It is, therefore, suggested that the "weight per cubic foot in comparison to over-all dimensions" be incorporated in the specifications for scrap, with the idea that all scrap be classified into special grades.

Before leaving this subject of weight per cubic foot, there is a point worth the attention of everyone interested in scrap; that is, the average weight of scrap which may be put in an open top gondola. An average of 22 cars of baled sheet scrap (20″x22″x18″) showed 21 tons to be the net weight, while in the case of the compressed sheet (7¼″x8″x28″) the net weight was 48 tons. If all scrap could be prepared to give the added weight to each car as shown above, perhaps demurrage, car handling charges and car shortages, in time of need, would be lessened to a marked extent.

7.—What effect does scrap have on the cost of the ingot produced? Depending upon the quality of the scrap and the amount used, the percentage of the metal going into ingots in comparison with the metal originally charged into the furnace is greater in those heats where scrap is used. This is one of the effects of scrap on the cost of steel production.

The following tables are offered to show the effect of scrap on the cost of production of steel. They are extracted from a paper, "Economic Significance of Metalloids in Basic Pig Iron in Basic Open-Hearth Practice," by C. L. Kinney, Jr.

Composition of Charges

Heat	Hot Metal	Scrap
Scrap charge	35%	65%
All other charges	65%	35%

"Low silica ore" = ore carrying 4.62% silica instead of 9.29%, as in other cases.

Pig Iron Analyses—Used in Heats	Carbon	Silicon	Phos.	Mang.	Sulphur
1, 2, 4 and 7	4.30	0.75	0.20	1.00	0.04
3 and 5	4.30	0.75	0.20	2.00	0.04
6	4.30	0.75	0.70	1.00	0.04
8	4.30	1.75	0.20	1.00	0.04

The scrap used was of the best grade of heavy melting steel.

No.	Type of Charge	Weight of Iron Ore, Lb.	Weight of Charges, Lb.	Tons of Ingots	Per-cent Ingots	Weight of Slag, Lb.	Weight of Iron in Slag, Lb.	Fuel per Ton, Lb.	Cost per Ton
1	Scrap heat	0	100,000	40.90	91.62	4,003	536	467	$28.91
2	Standard iron, low silica ore	4,746	104,746	42.57	91.04	18,975	1,274	511	30.23
3	High manganese iron, low silica ore	5,188	105,188	42.70	90.92	9,254	940	542	29.67
4	Standard iron, high silica ore	4,746	104,746	42.36	90.58	11,423	1,728	551	30.70
5	High manganese iron, high silica ore	5,188	105,188	42.44	90.39	11,965	1,432	583	30.38
6	High phos. iron	5,725	105,725	42.53	90.11	14,318	1,918	612	31.11
7	Excess limestone	4,746	104,746	41.97	89.76	15,465	2,536	633	31.68
8	High silicon iron	6,718	106,718	42.04	88.23	20,897	3,624	720	32.31

In comparing the above figures, it is immediately obvious that the scrap heat has decided advantages over any of the other types of composition. This table not only shows that the cost of production of steel by the use of scrap is less than when using a high percentage of pig iron, but that the amount of labor required to handle the slag is materially reduced, the iron loss is smaller and the return in ingots is greater with less fuel consumed.

The costs of the materials used in computing these heats are listed below:—

Basic hot metal	$28.00 per gross ton
Heavy melting scrap	24.00 per gross ton
Iron in ferromanganese	28.00 per gross ton
Metal from ore	12.00 per gross ton
Pure manganese from 80% ferro	162.50 per gross ton
Heavy scrap recovered	24.00 per gross ton
Pit scrap recovered	20.00 per gross ton
Limestone	2.00 per gross ton
Fluorspar	23.00 per gross ton
Calcined dolomite	9.00 per gross ton
Coal	7.00 per gross ton
Slag disposal	0.50 per gross ton

Mr. Kinney's paper states that "the scarcity and price of heavy melting scrap make it more economical to substitute the high percentage iron charge for the scrap." It further goes on to say, "while the scrap heat does not represent regular practice in the South Chicago district, it is included to show what economies might be

realized by this simple melting process, when the relative cost of heavy melting scrap and iron permit."

It is fully believed that with a different group of specifications and a more careful preparation, those classes of scrap which now seem to be of poor grade would be made available. This would materially aid in giving increased tonnages for consumption in the open-hearth, and thus help to overcome Mr. Kinney's objection and permit the simple melting process to become a realization with its resulting economies.

Specifications.

Scrap is purchased on mill specifications. It is shipped in accordance with these guides. The shipments, however, are governed, more or less, by the experience of the dealer with the consuming mills. It is the latter which really govern the quality of the scrap shipped. This condition is brought about because of the anomalies existing in the present specifications.

The grade, "No. 1 heavy melting steel," is covered by mill specifications. Those in existence today do not serve the purpose for which they were originally written. Instead of serving as a direct guide to the quality of scrap which might economically be used in the various mills, they are a subterfuge under which all grades of steel scrap, not especially described, may be shipped.

As an illustration of this, the following typical specification for No. 1 heavy melting steel has been taken as evidencing the inadequacy of such scrap descriptions.

"Railroad steel, such as axles, angle bars and splices, couplers and knuckles, cut steel bolsters, coil and leaf springs (all coil springs to be of ½-in. or larger diameter steel), crop ends from billets, blooms, sheet bars, structural shapes, rods, bars and plates (not needle or skeleton scrap), draw bars, heavy forge scrap, butts, rail ends and new mashed pipe ends (original diameter 4 in. and over, thoroughly flattened), oil well drill stems, bits and

jars, clean iron and steel No. 2 wrought, car body plate ¼ in. and heavier when cut 12 x 12 in."

The above is a composite of the heavy melting steel classification used by mills throughout the country. If this specification were analyzed, the following would be apparent:—

(1) Many of the kinds of railroad scrap listed are now sold as special grades of steel and bring a premium over the regular heavy melting grade. These special grades shown are: Coil and leaf springs, couplers and knuckles, draw bars and steel axles.

(2) Some of the scrap steel included in the specification would be sold as low phosphorus grades. These also bring a premium over heavy melting steel and therefore would not be shipped on such orders.

Exclusive of the railroad grades, the low phosphorus grades shown are: Forging steel scrap, plate scrap, oil well drill bits, jars and stems.

(3) Some of the kinds named in the classification come under the grades used by gray iron and malleable iron foundries: Angle and splice bars and rail ends (3 ft. and under).

(4) Eliminating "crop ends of billets, blooms, sheet bars, etc." from consideration, due to their being an intermittent source of scrap for the average dealer, the following grades remain, which actually are disposed of constantly as heavy melting steel: Cut steel bolsters, rods and bars, structural shapes, new mashed pipe (original diameter 4" and over, thoroughly flattened) and cut car sides (12 x 12 in.)

In comparison to this small list, the following grades, which are constantly shipped on heavy melting steel orders, are given:

Order of Value to Open-Hearth Plants	Grade
1	Ingot and billet crop ends
2	Miscellaneous rails
2	Steel-tired wheels
2	No. 2 wrought
3	Steel rolls

Order of Value to Open-Hearth Plants	Grade
3	Steel castings
3	Cast steel bolsters (whole or broken)
3	Cast steel truck frames
4	Cut structural shapes
5	Cut steel bolsters
6	Rods and bars
7	Bridge steel (cut)
8	Industrial steel scrap
8	Dealers' yard scrap
9	New mashed pipe ends (original diameter 4″ and over)
10	Car sides (cut 12″x 12″)

The numbers listed under "order of value to open-hearth plants" represent the efficiencies of the various grades which are shipped on heavy melting steel orders.

It is obvious that the present specifications do not have a true value. If they be required to remain the governor of scrap, then those grades which are specialties should be eliminated and the specifications extended to cover those grades actually shipped.

The present specifications, undoubtedly, covered the requirements of a few years ago. The items mentioned were at one time or another shipped to consumers. But progress in the scrap industry has been made. Specialty markets have been developed where "quality in scrap has been recognized" and a premium is paid for certain kinds. It would prove a waste of good material to ship "low phosphorus scrap" (railroad specialties included) to basic steel producers. Therefore, the need of an elimination of such grades of scrap from the heavy melting specifications is apparent.

The heavy melting steel specification is insufficient for mill purposes, but it proves adequate to the dealer who has an intimate knowledge regarding the class of scrap acceptable to a given mill. It, however, often works against him in the form of rejected cars. This not only applies to the dealer with a yard, but to the broker who is handling the cars for the dealer's account.

The yard dealer buys scrap to prepare for heavy melting steel. The specification, on which he is to ship,

specifically states certain kinds of scrap which are satisfactory to the steel works. He has a number of grades from which to select. For example, he can ship carloads of "miscellaneous rails," "No. 2 wrought," prepared "structural," and prepared "car sides" in completing his order. From the face of this, it seems to be an ideal condition, but it has two sides to it. The dealer must go out and buy up the various grades of scrap acceptable to the mill. In some cases, he must put work on it in order to meet the "charging box" size requirements. Some scrap requires more effort than other grades in this preparation. The cost of this fabrication should be considered with the purchase price of the "raw" scrap. But the market usually prevents full control at this point. Consequently, if it were his intention to ship one prepared grade, he is forced to buy up cheaper grades and expend a greater amount in its preparation. Thus he will fill an order with greater risk of rejections with hope of discharging his obligations. And the chances are, if the mill's supply of scrap is large, the rejections will be most heavy.

Along with the loss to the dealer by rejections is the loss to the mill in receiving inferior grades of melting stock. In the same light, if the dealer were to ship all A No. 1 scrap, the mills would benefit greatly while he would lose the warranted differential for such scrap. Then, there is the mixture of the various qualities of scrap which has its apparent effect on both. Because of these phases, it becomes apparent that a new method of grading, buying and selling scrap is essential.

For your constructive criticism, the following is offered:

A mill, outside of the territorial boundaries of the United States, set up certain standards by which to grade waste material. They were not entirely successful with this method, due to the lack of proper valuation of the scrap. The following is their revised classification, which is only tentative in its nature:—

1.—105% Scrap:—Ingot butts, condemned ingots, bar, bloom, billet, sheet and slab crops, rail ends, old rails (broken), old rails (unbroken and subject to allowance for shearing), defective billets, forge scrap (heavy), compressed sheet (weight 150 lbs. and over per cubic foot), steel wheels, scrap bar croppings, steel castings,* rolls (charging box size), cast steel truck frames,* arch bars and transoms, compressed turnings (240 lbs. and over per cubic foot).

2.—100% Scrap:—Plate scrap (cut), bridge scrap (cut), structural shape scrap (heavy), muck bar croppings, pipes, tube and socket scrap (mashed), No. 2 wrought; transom plates, bars, channels, angles, ties, flats, rods (No. 1 railroad melting steel), rolls (over charging box size), cut steel bolsters, rod and bars (cut).

3.—95% Scrap:—Rods and bars (merchant mill scrap), industrial scrap, horseshoe scrap, structural scrap (light), pinions, rolls (over charging box size and larger than No. 2), moulds and stools (broken).

4.—90% Scrap:—Heavy chilled ladle skulls and salamanders (broken), punchings, car sides (cut to size), rolls (over charging box size and larger than No. 3).

5.—85% Scrap:—Sheet scrap (weight 150 lbs. and under per cubic foot).

6.—80% Scrap:—Pipe scrap (unmashed), light ladle scrap and skulls, wire scrap (tightly bundled), nail scrap.

7.—75% Scrap:—Wire (loose baled), loose sheet clippings, nail whiskers.

8.—70% Scrap:—Pit scrap, cinder scrap, drillings, turnings and borings (steel).

9.—60% Scrap:—Boiler plate (cut and fairly free from lime incrustations).

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*When this type of scrap is used in large percentages, these items take the grade lower due to their analyses, i.e., steel castings would be equal to 100% scrap when used in amount greater than 10% of the charge.

10.—50% Scrap:—Heavily limed iron and steel scrap, burnt iron, burnt annealing boxes, heavily rusted scrap.

The above list has been calculated on the basis of the weight per cubic foot of scrap (in charging boxes) and the ability of the scrap to produce steel. The "percentage" indicated has a relation to the price of basic pig iron. An exact percentage of the price of this commodity cannot form the basis of the price to be paid for scrap, due to the fact that where hot metal is used a differential must be taken from the price of cold pig. Further, the difference in handling charges of these materials must be considered. It is commonly agreed, however, that when the price of the 105% grade of scrap and basic pig iron are equal, the 105% scrap would return some economy to the consumer.

It is, therefore, suggested that this more modern method of evaluating scrap, which tends to eliminate the elements of risk and unfair practices in the scrap business, be investigated. In this connection, each grade would become a specialty and be bought on that basis.

The Specialty Markets.

The blast furnace, the acid open-hearth, the electric furnace, the converter, crucible, cupola and malleable foundries, and in some instances the basic open-hearth plants are consumers of special grades of scrap iron and steel.

The blast furnace is an important consumer of some grades of scrap. The tonnage used is on the increase. Blast furnaces are looking into the use of scrap, more and more. The reason for this is obvious when one considers that without additional fuel, the total burden may be increased five to eight per cent with "free" melted scrap. The report of this Institute shows an average consumption of 0.135 tons of scrap, scale, cinder, etc., out of 1.933 tons of metallic material required to make one ton of pig iron in 1923. The grades of scrap,

used today in blast furnaces, are cut annealing pots, borings, short turnings and bushelings. The use of scrap in a blast furnace is not one of metallurgical reactions, but constitutes a regular melting condition.

The acid open-hearth melters have more or less severe problems to meet. Consequently, their specifications have been constantly revised to take care of the existing exigencies of the times. They, too, have neglected, however, the effect of the weight per cubic foot in comparison with lineal dimensions. This factor is not so important to them because their tonnages are markedly smaller than the big basic furnaces.

The demand on the scrap market for "low phosphorus" grades for acid open-hearth use has been fairly constant during the past few years. The kinds of steel scrap adaptable to such use cover not only the "low phosphorus" material, but the railroad specialties and automobile forging stock, which appears on the market from time to time. These grades take a premium over the regular run of scrap. The purchasing agents for such melters have recognized that quality exists even in scrap and are willing to pay the added cost.

The converter and crucible foundries have, through their years of experience, learned that certain grades will lend themselves to their requirements. Naturally, the specifications covering the purchase of their scrap have a very definite purpose.

The same holds true for those basic open-hearth plants which require special grades in the manufacture of their products. These are the plants which are operating on very high percentages of scrap. In one instance where the furnace charge is upwards of ninety per cent scrap, the plant is an important consumer of "couplers and knuckles." The ease of operating to a definite analysis when good quality materials, such as the aforenamed, are used, becomes obvious from the following table:—

SPECIALTIES

Grade	Carbon	Silicon	Sulphur	Manganese	Phosphorus
Axle turnings	0.35–0.55	0.20	0.040	0.80	0.040
Couplers and knuckles	0.50–0.70	0.35	0.040	0.75	0.040
Forge flashings	0.25–0.45	0.10	0.040	0.65	0.040
Frogs and switches (cut)	0.55–0.75	0.20	0.040	0.90	0.040
Heavy melting steel	0.15–0.40	0.10	0.050	0.60	0.050
Locomotive tires (cut)	0.50–0.85	0.30	0.045	0.70	0.045
Low phosphorus steel	0.15–0.35	0.10	0.045	0.65	0.040
Machine shop turnings	0.15–0.45	0.20	0.050	0.60	0.050
Punchings—low phos	0.10–0.20	0.10	0.040	0.60	0.040
Railroad wrought	0.05–0.15	0.10	0.040	0.40	0.040
Shoveling steel	0.15–0.30	0.10	0.040	0.60	0.040
Small structural	0.18–0.24	0.15	0.050	0.50	0.040
Springs (coil and leaf)	0.85–1.05	0.20	0.040	0.45	0.040
Rails (steel)	0.50–0.85	0.20	0.040	0.90	0.040

When a heat is to be put into low carbon castings, a definite amount of carbon to take care of oxidation must be charged into the furnace at the start. It is better to have this carbon dissolved in the metal charged, rather than to use an outside carburizing agent. In view of this, if springs, couplers and knuckles, rails and locomotive tire grades are used in a high scrap heat, a goodly per cent of carbon is charged, which should allow the heat to be tapped in the range of 0.20-0.30 carbon, without the use of outside agents. Hence, a simplification in the working of the heat results and a greater intrinsic worth is therefore placed on such scrap. The element manganese will also be present in higher average percentages which again builds up the value of these special grades. Again, in the lowering of certain chemical elements in the mixture, certain of these specialties will have an active part. Such is the use of "premium" grades of scrap, and without doubt scrap of every description may have its value appraised accordingly.

The electric furnace has proved a source for the consumption of various special grades of scrap. The tonnage of steel produced from such units has increased enormously during the past twelve years. It is recognized that the greater amount of this steel is made from bessemerized hot metal, but the ever increasing small

castings foundry is a factor to be considered. Here we find, in addition to the kinds shown in the previous list, the consumption of such grades as punchings, nail whiskers, shoveling, etc. These furnaces operate on one hundred per cent scrap and are either acid or basic lined. The scrap furnished must be in accordance with the type of the process. This industry is another which has learned that a certain kind of scrap renders a service which makes it deserve a differential over other grades. It is also the one melting medium which offers ready relief for high sulphur scrap. The sulphur is easily removed by a slag in the basic electric furnace process.

The electric furnace producing ferro-alloys provides another consumer of shoveling turnings. This development is of recent years and consequently lessens the supply of this melting stock.

Then, there is the gray iron foundryman who, during the past few years, has been disillusioned. He had long supposed that good gray iron castings required "at least fifty per cent pig iron." Today, by proper operation, good castings are produced with one hundred per cent scrap. A striking illustration of this advancement is the chilled iron car wheel manufacturer. There is a general tendency toward the use of special grades of scrap in the production of gray iron castings. Such prepared grades are an economy to the consumer.

One of the most interesting scrap consuming developments of the past few years is the Kranz process for the production of malleable iron. This method of making malleable castings has sidetracked pig iron altogether and scrap with ferro-alloys rules the mixtures. The advent of such processes makes great inroads on the consumption of pig iron and lessens the supply of certain grades of scrap. Each process finds that "any old grade" will not do. It must have its special classes of scrap carefully specified in order to work successfully and economically.

These instances have been cited in order to show the

ever increasing utilization of scrap in the manufacture of iron and steel products. They also show that the general trend is toward specialties rather than general specifications. In other words, perhaps the minor industries are leading the way for the major producers in giving scrap a value that it deserves.

Statistics.

Where does all this scrap come from? It is practically impossible to cite the origin of all the scrap produced. The largest tonnages are made within the steel mills. This scrap never finds its way to the market, but is remelted by the producer. Then, the industrial concerns and railroads enter for their share in enlarging the amount of scrap for consumption. Finally, the "junk" collectors travelling everywhere collect their wagon loads and take them to yards where scrap is assembled and sorted. No actual records are available which show the tonnages produced. This may be due to the way in which the scrap business grew, or perhaps to the fact that the intrinsic value of scrap is alone in the price which it brings. When the price of scrap is high, then larger tonnages are brought in to scrap centers. Due to the railroad freight rate structure, rising prices in scrap do not make available all the scrap collected in areas surrounded by concentric circles. Rather, the districts are confined by eccentric circles. This fact introduces another uncertainty in the collection of scrap.

Therefore, the tonnage of iron and steel scrap produced annually remains an unknown figure to the buyer and seller of this commodity. The same holds true for the consumption of this raw material. There are estimates, guesses and assumptions to cover the tonnages involved, but there are no actual statistics or barometers to help govern the judgment of one interested in scrap. The trade papers alone are the facilities used in swaying judgment of the conditions surrounding the scrap market.

But this information is only in the form of news items and based upon hearsay.

With the ever-increasing consumption of scrap in the processes for the manufacture of steel, the subject assumes an importance second only to pig iron in the industry. In considering pig iron, however, we have statistics which show, to a nicety, its production and consumption. In contra-distinction to this situation, we are left in ignorance of the conditions pertaining to scrap iron and steel.

Up to the present time it has been admittedly impossible to accurately ascertain the potential resources from which this secondary ferrous material of the iron and steel industry originates. But it is known that the quantity of scrap produced is in relative proportion to the ingot and pig iron production of the country. Its consumption, however, must be based upon the "going" melting capacity of the mills and foundries.

The accumulation of actual statistics of the production and consumption of iron and steel scrap, under the present conditions, has been impeded by the uncertainties involved. If it were possible to accurately calculate the amount of scrap produced by using a percentage of the finished steel, based on the life of the products made therefrom, the problem would be simplified. There is an uncertainty, however, regarding the life of steel products. Further, there is that amount of steel which goes into obsolescence, or "never returning steel" scrap, which makes such a figure amount to no more than a guess. The only other apparent way to arrive at the tonnage produced was to ask producers of scrap to furnish us with their figures. This compilation was exceedingly difficult, due to the fact that even the records of the large producers were far from complete and had to be brought up to date, while the small producers had no records at all. The figures shown in this paper are those arrived at by taking concrete productions of scrap, by groups of recognized industries, and applying these to their various

classes. The statistics shown should be given tolerance, because actual figures are used in arriving at the results.

The total annual tonnage of scrap produced in the country, by taking ten-year averages, shows an amount of 24,863,644 tons. Of this amount approximately 11,944,223 tons find their way to market, to be handled by dealers and brokers. The remaining tonnage stays within the confines of the steel mills for re-melting purposes.

The above tonnages of scrap are produced about as follows:—

Scrap Never Appearing on the Market		
Steel Mills:		
Butts, crops, etc	7,209,012 tons	
Scale	1,062,091 tons	
Ladle, pit and runner scrap	1,863,318 tons	
Foundry:		
(Malleable and gray iron) Internal scrap	1,910,000 tons	
Cast iron car wheels exchanged for new car wheels	875,000 tons	
Total		12,919,421 tons
Scrap Appearing on the Market		
Railroad scrap	2,769,809 tons	
Industrial scrap	2,629,085 tons	
Automobile scrap	406,979 tons	
Country scrap (approximate)	5,000,000 tons	
Imports—minus exports	1,138,350 tons	
Marketable scrap		11,944,223 tons
Total tonnage produced		24,863,644 tons

The steel mill scrap was estimated on the basis of finished steel produced from ingots. The steel mill scale scrap was arrived at by taking an average of the amount produced in six mills. This composite figure showed a 3% loss from ingot to finished steel. In the same way, the figure for "ladle, pit and runner scrap" was obtained. This proved to be 5% of the metal charged into the furnace.

The foundry scrap (internal) was obtained by taking 40% of the average melt of the foundries in the country.

The cast iron car wheels consumed on exchange contract was an average obtained by taking the number of

new cars purchased and multiplying it by eight (the number of wheels). This would represent the new wheels required. Taking the production of the country as 3,500,000 wheels and subtracting the new wheel figure from this, the number of exchange wheels may be calculated. The result checked with the figures of several railroads which were available for this purpose.

The railroad scrap figure was based on reports received from seven different trunk lines, representing 33% of the trackage in the country, giving the total amounts of scrap produced by them. A ten-year average was taken. The amount of trackage represented by these roads was divided into this figure. This gave 10.9 tons of scrap produced annually per mile of track. The system of railroads, during the last ten years, has averaged 254,111 miles of track. By the use of this factor of the scrap produced per mile of track and the average trackage, the tonnage shown in the list was computed.

The industrial and automobile scrap was computed by the use of averages of scrap per ton of steel consumed by the manufacturers.

The country scrap figure is only an approximate one, based on assumptions as to the length of life of finished products. This, together with approximations by some of the leading scrap authorities in the country, lead to the acceptance of the tonnage shown.

The eleven million tons appearing on the market have long been offered by grades. In some instances the tonnages offered have been gross tons, and, then again, other grades are net ton offerings. The Eastern States have fairly well standardized all their grades on the gross ton basis, while in the West, a mixed condition of net and gross still appears.

It is now advocated that the standardization be changed in the East to the net ton basis and the mixed classification of the West be eliminated in favor of the net ton standard. This is against the present trend of opinion, but when one considers the problem from the

accounting end, the amount of labor saved by the net ton standard will immediately become obvious. It is, therefore, hoped that this suggestion will be accepted.

Relation of Pig Iron to Scrap

The price of pig iron should have a direct relation to the value of scrap. When pig iron is high and scrap low, the consumer should take advantage of the situation and alter his mixtures to take care of increased percentages of scrap.

Scrap is an essential in the production of good castings. With careful manipulation of the melting medium, the percentage of scrap may be raised to 100% without creating casting losses. The same is true in ingot production. Of course, in the large steel plants there is an amount of hot metal which must always be consumed. But in the smaller mills, without blast furnaces, 100% scrap mixtures should be approached when conditions warrant their use.

Scrap should have a direct relation in price to that of pig iron. Likewise, a grade of scrap should be given a value which compares with its ability to return economy. Up to the present time, the relation of prices between pig iron and scrap has been rather chaotic.

For the information of the user of scrap, Table A has been prepared in order to show the relation of the prices of pig iron to several grades of scrap. This table shows the "spreads" which have existed between these materials annually and during groups of years arranged in business cycles. A careful study of this table may bring to one's mind several instances when the relative prices have been far from proportional. It is hoped that by a reclassification of scrap, such occurrences will be eliminated.

The prices shown in this table are taken from a trade paper, *The Iron Age*. These prices represent what is known as the market. After all, they are of an uncertain

COMPARISON OF AVERAGE PRICES OF PIG IRON AND SCRAP AT CHICAGO, FROM 1905 TO 1923, INCLUSIVE.

Year	No. 2 Foundry Pig Iron, Per Gross Ton			Heavy Melting Steel Scrap, Per Gross Ton			Heavy Cast Scrap, Per Net Ton			Railroad Malleable Scrap, Per Net Ton			Cast Iron Car Wheels, Per Gross Ton			Old Steel Rerolling Rails, Per Gross Ton			No. 1 Railroad Wrought Scrap, Per Net Ton		
	First Half	Second Half	Year	First Half	Second Half	Year	First Half	Second Half	Year	First Half	Second Half	Year	First Half	Second Half	Year	First Half	Second Half	Year	First Half	Second Half	Year
1905	$17.61	$17.68	$17.65	$13.72	$14.20	$13.96	$13.19	$13.81	$13.50	$13.12	$13.91	$13.51	$15.60	$16.15	$15.88	$14.81	$15.27	$15.04	$15.89	$16.39	$16.14
1906	19.15	21.70	20.43	13.65	15.83	14.74	13.46	15.63	14.55	13.77	15.40	14.59	18.72	20.52	19.63	16.01	18.30	17.16	15.09	16.15	15.62
1907	26.27	22.73	24.50	16.03	14.13	15.08	18.65	15.89	17.27	16.59	14.61	15.61	24.65	23.79	24.22	18.84	16.15	17.50	15.64	13.63	14.64
1908	17.92	17.21	17.57	11.38	13.52	12.45	12.27	13.11	12.69	10.31	12.57	11.44	15.40	15.18	15.29	12.83	16.08	14.44	11.39	13.51	12.45
Average N. T.									14.50			13.79									14.71
Average G. T.			20.04			14.06			16.24			15.44			18.75			16.04			16.47
Comparison						−5.98			−3.80			−4.60			−1.29			+1.98			+2.41
Per Cent						70.15			81.03			77.04			93.56			114.08			117.14
1909	16.68	18.30	17.49	13.32	15.58	14.45	12.96	14.62	13.79	12.22	14.49	13.35	15.13	17.60	16.37	14.52	17.11	15.82	12.70	14.82	13.76
1910	17.93	16.24	17.09	14.61	12.25	13.43	14.01	12.63	13.32	13.84	11.16	12.50	16.83	14.05	15.44	17.52	15.16	16.34	13.97	11.94	12.96
1911	15.25	14.40	14.83	11.43	10.41	10.92	11.69	10.46	11.07	10.65	9.88	10.27	12.96	12.64	12.80	13.38	12.48	12.93	11.73	10.74	11.23
1912	14.17	16.47	15.32	11.36	12.88	12.12	11.65	12.94	12.30	11.02	12.86	11.94	13.43	15.23	14.33	13.07	15.30	14.19	12.00	13.08	12.54
1913	16.85	14.81	15.83	11.83	9.95	10.89	12.12	10.41	11.27	12.62	9.85	11.24	16.04	12.35	14.20	14.65	12.01	13.34	11.87	9.74	10.81
1914	14.00	13.20	13.60	9.81	8.94	9.38	10.25	9.15	9.70	9.41	8.29	8.85	11.75	10.61	11.18	11.46	10.46	10.96	9.04	8.28	8.66
Average N. T.									11.91			11.36									11.66
Average G. T.			15.69			11.86			13.33			12.72			14.05			13.93			13.05
Comparison						−3.83			−2.36			−2.97			−1.64			+2.07			+1.19
Per Cent						75.58			84.95			81.07			89.54			117.45			110.03
1915	12.99	15.03	14.01	9.39	12.42	10.91	9.03	10.89	9.96	8.06	10.75	9.41	9.93	12.33	11.13	10.08	13.38	11.73	8.84	11.68	10.27
1916	18.78	21.74	20.26	15.66	17.70	16.68	12.79	13.40	13.10	13.36	13.46	13.41	13.69	14.55	14.12	17.17	20.01	18.59	15.95	18.37	17.16
Average N. T.									11.53			11.41									13.71
Average G. T.			17.13			13.79			12.91			12.77			12.62			15.16			15.35
Comparison						−3.34			−4.22			−4.36			−4.51			+1.37			+1.56
Per Cent						80.50			75.36			74.54			73.67			109.93			111.31

1917	38.67	43.94	41.31	26.42	29.30	27.86	20.23	23.86	22.05	21.38	28.13	24.76	24.56	30.40	27.48	33.00	38.16	35.58	29.51	32.97	31.25
1918	33.00	33.50	33.25	29.44	27.88	28.66	26.69	28.69	27.69	28.09	28.79	28.44	29.50	28.62	29.06	34.37	32.83	33.60	30.49	28.82	29.66
Average N. T.									24.87			26.60									30.45
Average G. T.			37.28			28.26			27.85			29.79			28.27			34.59			34.10
Comparison						−9.02			−9.43			−7.49			−9.01			+6.33			+5.84
Per Cent						75.80			74.70			79.90			75.83			122.39			120.66
1919	28.69	29.62	29.16	16.13	20.05	18.09	21.15	26.24	23.70	15.94	21.00	18.47	22.48	26.62	24.55	18.16	28.63	23.40	16.45	20.87	18.66
1920	42.44	42.60	42.53	23.90	21.74	22.82	37.48	29.52	33.51	27.87	23.55	25.71	36.88	34.03	35.46	33.07	30.73	31.90	26.49	20.87	23.68
1921	25.61	20.15	22.93	12.68	11.29	11.98	14.96	13.05	14.00	13.38	12.38	12.88	16.60	14.79	15.70	13.90	13.04	13.47	11.46	11.16	11.31
1922	20.70	29.00	24.85	13.07	17.05	15.06	14.57	19.63	17.10	13.19	19.36	16.28	17.03	22.88	19.96	13.81	18.14	15.98	11.69	15.78	13.74
1923	30.85	25.46	28.16	20.51	15.59	18.05	23.71	19.01	21.36	23.54	18.38	20.96	26.01	19.23	22.62	21.91	16.79	19.35	18.36	14.19	16.27
Average N. T.									21.93			18.86									16.73
Average G. T.			29.53			17.20			24.56			21.12			23.66			20.82			18.73
Comparison						−12.33			−4.97			−8.41			−5.87			+3.62			+1.53
Per Cent						58.24			83.16			71.52			80.12			121.04			108.89
Summary									G. T.			G. T.									G. T.
1905–08			20.04			14.06			16.24			15.44			18.75			16.04			16.47
1909–14			15.69			11.86			13.33			12.72			14.05			13.93			13.05
1915–16			17.13			13.79			12.91			12.77			12.62			15.16			15.35
1917–18			37.28			28.26			27.85			29.79			28.27			34.59			34.10
1919–23			29.53			17.20			24.56			21.12			23.66			20.82			18.73
Average G. T.			22.67			15.66			18.39			17.30			18.91			18.49			17.73
Comparison						−7.01			−4.28			−5.37			−3.76			+2.83			+2.07
Per Cent						69.07			81.12			76.31			83.41			118.07			113.21

NOTE.—Prices from the *Iron Age*. No. 2 Foundry used as base grade because Basic Pig Iron is not quoted for Chicago District. The comparisons given which bear a minus sign and show percentages less than 100 per cent are comparisons of the price of Scrap with No. 2 Foundry Pig Iron; those bearing plus signs and showing percentages over 100 per cent are comparisons of Scrap prices with the price of Heavy Melting Steel Scrap.

nature. The method of collecting market information for trade papers varies with the district quoted. It should become the aim of all trade papers to quote prices, wherever possible, which the consumer is willing to pay for scrap. In the absence of consumer transactions in a district, then dealers' prices should become the guide. The establishing of market prices is a difficult task. Therefore, the consumers and dealers should willingly co-operate with trade papers to the end that false market quotations will cease to exist.

Railroad Scrap

The railroads of this country are among the largest producers of scrap. They have made marked strides in the classification of their grades. The most notable work was performed by the Railway Storekeepers' Committee, at Atlantic City in 1921, when specifications shown in circular No. 2193 were adopted.

Certain railroads have ignored these classifications, thus creating confusion in bidding on their scrap lists and making it necessary to ship certain items on these lists to scrap yards, there to be assorted before the material will be acceptable on mill orders. There are other roads which should be sincerely congratulated in their attempts to maintain these classifications and bring about progress in the scrap industry.

There are various methods of offering scrap on the market. Certain railroads would clear away an awkward position if they would eliminate their present practice of sending out "blank" lists. A dealer would have better chances of bidding if he knew the tonnages involved. The bids made by dealers are either given with the hope of applying the material directly on an order or of shipping to his yard. A greater hazard involves the dealer when he is bidding for an indefinite tonnage. When any item is offered it should be stated in tons and not in carloads, as is often the practice even on "specified"

lists. The "expectancy" to the dealer is something of importance and it seems only fair that he know whether his bid will place him in a long or short position on his order book.

The equipment in which scrap is shipped is an important consideration to the consumer. If the consumer requires a bottom drop car for cheap handling of a material, it is perhaps essential to economy that he be given this type of equipment. Again, it would prove a great drawback to the consumer of car wheels if they were shipped in box cars. There are some roads who try to satisfy the users of their rolling stock and it is hoped that all roads will, as time progresses, lend their aid to this cause of economy.

Finally, the meeting at Atlantic City advocated the following:—"Net ton: It is further recommended that the sale of all scrap be made on a net ton basis." This is cited to bear out the contention made in the earlier part of this paper. It is believed that if this were generally accepted, along with an adjustment of freight rates on the net ton basis, a forward movement in the scrap business would be felt.

Consumers of Scrap

The consumers of scrap have a great deal to do with the existing conditions in the scrap business. They should have a uniform scrap iron contract and exact no unusual discounts. The contract should contain a standard classification which should be fair alike to the consumer and the dealer.

When scrap is received at a consuming point it is inspected. This inspection should be rigid but also fair and without regard to market conditions. The present specifications contained on some contracts permit unfair inspections and thereby place the shipper in a position in which he is compelled to rely on the fairness of the consumer.

When a consumer suspends shipments of scrap, he usually causes the dealer embarrassment. The latter buys the majority of his material from railroads and manufacturing industries who force him to accept their deliveries without regard to exigencies. Consequently, when shipments to consumers are held up, the dealer must either stand demurrage on his cars of scrap or divert them to a yard where his costs are increased by the rehandling of the material.

Consumers of scrap buy on a basis of "delivered price." Consequently, their attention has never been generally called to the freight rates on this commodity. It might be of interest to know that even though the value of scrap is less than that of pig iron, the prevailing freight rates are usually higher. The free movement of scrap is greatly restricted, especially on low markets, by the existing high freight rates. Possibly, if freight rates were adjusted, the movement of scrap from non-consuming territories to consuming areas would be greater, due to a more advantageous price, at the point of origin.

Some producers of scrap send out lists to both dealers and consumers. The consumer often bids on these lists against a dealer with whom he has an order. The dealer tries to obtain his scrap from these lists to fill an order at a given figure. The consumer in overbidding the dealer's price forces the market up. This places the dealer in a difficult position. A consumer of scrap should make an appraisal of the scrap dealer as an adjunct to his business. By comparing the service rendered by a dealer with the estimated cost of a department in the consumer's organization to provide an adequate supply of scrap, the value of the dealer could be established. If such a comparison reveals that the dealer is a necessity and performs a real service, consideration should be given to co-operating with him, rather than competing against him at his sources of supply.

Mill weight tickets are an essential to the dealer. His

shipments of scrap are to be governed by the consumer's weights. He sometimes buys this scrap from a producer to be paid for in accordance with the mill weights. Consequently, to keep his bookkeeping correct, he should have the mill weight tickets to check against the invoices rendered. At the present time, weight tickets are not always furnished unless demanded. This is especially true in the case of some mills. It would seem that by the furnishing of mill weight tickets on each car received some of the unfair practices existing in the scrap business would be eliminated.

Dealers in Scrap

The days of topped cars, short weights, over-billing of cars in order to receive weight certificates, mixing mill scale with borings and annealing pots with heavy melting steel and such other historic practices are being eliminated by the rigid inspection of the consumer. Further, the cost of reconsigning cars rejected because of such conditions is too huge for these dishonest methods to long continue.

Scrap markets are manipulated constantly to the profit of some and the distress of others. A more stable market is greatly to be desired. This would place scrap values on a par with other kindred iron and steel products. Dealers may be able to constructively aid in stabilizing these markets if they will make their bids in accordance with the grades they desire to ship.

Shipments of scrap are always looked upon with some doubt. A dealer will be able to relieve himself of any suspicion when he is able to furnish weight certificates with each car.

Modern cost systems in scrap yards are practically unknown. Consequently, dealers over-bid on unprepared scrap and thereby meet with a loss after the costs of preparation are added to the initial cost of the scrap.

Based on actual experience in the operation of a scrap yard along business lines, a correct estimate of

the handling costs per ton of scrap, in and out of the yard, amounts to $3.35. This represents an average cost of handling a large volume of scrap of all grades, some requiring no preparation, while others are given extensive fabrication. Included in this figure are all charges which rightfully belong to the cost of operating a scrap yard, such as rent or interest on real estate investment, depreciation, insurance, taxes, direct labor, repairs and running expenses of the yard. This figure does not include any charges for direction or supervision.

When this cost figure is considered, perhaps it will become obvious why some yards are forced to neglect the careful preparation of scrap. It may even explain some of the reasons why the old malpractices existed.

Summary.

1.—The scrap industry, in volume of tonnage, has grown to take its place alongside of pig iron, though second in rank in the production of steel. It serves as a medium for the conservation of the natural resources of the United States.

2.—Steel is produced of better quality and in greater volume per unit of time at less cost by the use of scrap.

3.—The metallurgical phases are all-important to the growth of the scrap business.

4.—A new and more concrete specification covering the grades of scrap is required by the industries as a whole.

5.—Railroads, dealers and consumers alike have problems which are yet to be cleared away if the scrap business is to be elevated to its proper rank in the iron and steel industry.

In conclusion, the author expresses his sincerest thanks to Messrs. C. L. Kinney, Jr., of South Chicago, Illinois; W. A. Maxwell, Jr., of Indiana Harbor, Indiana; Richmond Nicholas, of Chicago, Illinois, and the many railroads and industries who have all aided in the accumulation of the data contained in this paper.

The Chairman (Mr. E. A. S. Clarke): Gentlemen, a study of your expressions during the reading of those two papers leads me to conclude that the subject is of very great interest. I am sure you will be glad to hear the discussion and I will ask Mr. Joseph Michaels, of the Hyman-Michaels Company of Chicago, Ill., to open the discussion. May I interject one word; Mr. Lowry's paper as you know, has been somewhat abbreviated. The full printed copy is available. Probably many of you have it, but I think I should say that you will all profit by a careful study of it, as well as of Mr. Vernon Phillips' paper.

Discussion by Joseph Michaels

President, Hyman-Michaels Company, Chicago, Ill.

A discussion of the purely commercial aspect of the scrap iron situation must necessarily contemplate a review of the very splendid papers read by both Mr. Phillips and Mr. Lowry.

Both papers refer frequently to alleged irregular practices on the part of shippers of scrap iron, as well as on the part of consumers who receive it. There is undoubtedly an over-emphasis of this feature. Irregular practices or violation of contracts are indicative of the character of the particular parties involved rather than of the business in which they are engaged. Where such conditions do exist, it seems to me that it is simply a question of common honesty. They cannot be cured by regulation but only by elimination. Of course, with a commodity so irregular in form, size and condition as scrap iron, there is bound to be difficulty in getting an exact specification or an exact compliance therewith. It is necessary that some discretion be used both in making the specification and in the subsequent inspection of the shipment. However, where there is intentional falsification on either side, the widest publicity should be given to such transactions, and the parties thereto, so as to effect, if possible, the elimination of both.

Mr. Lowry, as a metallurgist, naturally in his suggestions concerning specifications has in mind the maximum amount of efficiency at the open-hearth. On the other hand, Mr. Phillips, as a dealer, lays emphasis on the available supply, its character, and on the improvement of the grade.

In view of the fact that there is a large tonnage of lighter materials on the market, such as are produced by the automotive industry and from steel cars, the mills should give the greatest amount of study to the improvement of their facilities so as to make all these grades available for their practice; particularly, as Mr. Lowry emphasizes the desirability of selecting some of the better grades of scrap for the use of plants such as steel foundries, electric furnaces and others who can only operate with these special grades.

Now, it must be borne in mind that the scrap dealer does not produce any of the scrap he ships. He prepares or distributes it. The railroads and factories who do produce a large volume of scrap, while preparing it so as to get its maximum value, must not be asked to intensify the operation to the extent that the cost of doing so would be out of all proportion either to the value gained or the quantity of higher grade materials thus selected. It is obvious that the closer the selection with a view of obtaining the higher grades of scrap in lots by themselves, just to that degree is the general pile of scrap depreciated in quality. Besides, it is a question whether the amount of higher grade material, as carried in some of the suggestions of Mr. Lowry, will be of sufficient quantity to make a dependable source of supply to the plant that adjusts its practice only to the use of such better grades. Of course, it is necessary to skim a certain amount of cream from the milk, but it must be borne in mind that the residue is after all skimmed milk, and must be either used as such or wasted.

Mr. Phillips makes a suggestion which, I believe, if

enlarged upon will solve some of the problems connected with this condition. As much thought should be given to the class and nature of the material available as to the quantity. If we would realize that so much of the recoverable scrap at this time is of this lighter nature, it is obvious that the open-hearth should adjust its practices so as to avail itself of this constantly growing tonnage of raw material, rather than to restricting its uses.

If every buyer, either by contract or by practice, would accept shipments containing a certain percentage of the lighter grades (clearly specifying them, and always loaded in separate cars), as a part of each transaction, there would be provided a definite outlet for these lighter grades in connection with the heavier ones. All melters, too, would receive a grade of scrap that would be consistent with the source of supply, and similar to that received by other plants operating on the same basis. The producer could thus intelligently prepare the scrap; the dealer with a certain degree of accuracy could figure the supply, and the consumer would know the class of material that he could definitely expect to receive from time to time. With the authorized specification for these lighter grades and the resultant preparation in accordance therewith, a ready outlet being provided, there could be no temptation to mix them with the other grades. It can readily be seen that it would be unnecessary to mix the two grades either intentionally or otherwise. I believe this method of buying does prevail with many and should be a more general practice.

Mr. Lowry definitely states that price is the intrinsic value of scrap; and in a general way this is true. We must therefore be careful that we do not, by compelling the too intensive manufacture and preparation, increase the cost beyond its economic value.

As an illustration, I want to refer to one class of scrap that represents one hundred per cent of the raw

material of the plants that use it. I refer to rerolling rails, of which there is a consumption of between 800,000 to 1,000,000 tons per annum. The consumers of this commodity formerly had a specification for rails that required almost individual inspection to insure their coming up to the requirements. By liberalizing the specifications, these mills have obtained a larger supply at a cost relatively small as compared to the miscellaneous rails from which they are selected. If, as a result, there is an accumulation at their plant of a certain amount of material not available for their purposes, the difference in price at which they sell it for remelting purposes is small compared to the premium they would have to pay for their total tonnage, if the rigid specifications were persisted in.

As pointed out by both gentlemen, price does not increase volume. No railroad will wreck an engine or destroy a bridge simply because of its increasing scrap value; nor will a mill cut a larger crop end for the same reason. However, as both papers indicate, price will increase the radius of the circle within which it moves. Thus, the entire commercial proposition is a matter of collection and distribution which, when intelligently handled, will avoid unnecessary movement and cross shipments from one center to another.

Probably modesty has prompted the gentlemen to refrain from laying sufficient emphasis on the importance of the scrap iron dealer as the proper distributing agency of this commodity. There are located in practically all the steel consuming centers large responsible dealers ready to supply their customers at all times with their needs. These dealers in turn trade largely with each other at other locations. The very nature of their transactions results in augmenting local supplies where they are most needed, and avoids a serious loss in unnecessary cross shipments. Investigation of the origin of the shipments of large dealers from whom the mill purchases would develop the fact that ninety per cent

of such shipments are never handled or seen by that particular dealer. The balance represents material which, as a distributor, he buys from the producer such as railroads, mills and others, and like any other prudent businessman, he purchases this on like condition and specification that he is compelled to sell under.

Mr. Phillips suggests that the large investments made by the scrap dealer in his yard for machinery, equipment, etc., have not particularly reduced the cost of his production. While this may be true in a sense, I cannot entirely agree in that conclusion. This equipment has been introduced owing to the different nature of the material handled by the scrap dealer than heretofore. He has to take care of the wreckage of steel cars, large locomotives, underframes and heavy equipment that is now finding its way to the scrap yard. As a matter of fact, this class of material could not be handled at all with the very limited facilities that were formerly the equipment of the scrap yard. Thus, for the purpose of discussion of the relative costs as suggested by Mr. Phillips, he must take into consideration that it would be impossible to handle the class of material that the dealer is now compelled to handle, with the facilities that he had heretofore. In figuring on conditions and particularly costs in the scrap iron yard, these large fixed investments must be considered as a new phase of the situation. As this material, put by the dealer in its first process of manufacture is of great value to the steel trade, every encouragement should be given to the extension of the efforts of these operators.

Mr. Lowry's figures on the sources of supply are as accurate as are readily obtainable. I do not think, however, that they represent the true condition. For instance, the figure as to the country scrap is out of all proportion compared to the others. I assume that he meant by this designation to cover all grades of scrap not otherwise specifically mentioned. In the automobile industry we understand that, in what is known as the

Detroit District alone, there are produced between 60,000 and 70,000 tons of scrap per month, which in itself would represent some 700,000 or 800,000 tons per annum. This class of scrap material is necessarily of a light grade and not so desirable. However, the open-hearth, in figuring both on availability and desirability must take this large tonnage into consideration. As far as what is called strictly agricultural scrap is concerned, as Mr. Lowry probably knows, owing to the very high cost of labor and freight, a great deal of this has been allowed to lie and rust in the places where it has accumulated, and thus has been lost to the market. Then, too, the relatively low price obtainable for this class of material, together with the high cost of labor and transportation, has not given the dealer any incentive to accumulate it. I believe that the tonnage of railroad scrap is greater than as suggested by Mr. Lowry. While the method of arriving at it is a fairly good gauge, yet as time goes on there is naturally a far greater amount of replacement and reconstruction which produces larger tonnages of scrap than was the case when the railroads were in their first process of construction.

Both papers lay emphasis on the element of speculation, and both suggest as a remedy a less spasmodic buying program on the part of the consumer. Scrap at a low price is a very stable security and there should be little difficulty on the part of the large consumer to finance and carry a certain amount of this material even though he has no present need for it. It has often been suggested that capacity of the open-hearth, rather than the actual state of the order books, should influence the purchase of scrap when it is available, thus only can the consumer derive some benefit from the period of depression; at least, to the degree of securing this valuable raw material at a far lower price than he would actually have to pay when there is a general demand for it. In this way, a steady movement of scrap will be

assured when it is available and there will be a supply on hand at the mill when the demand springs up. The movement of scrap from place to place simply for storage purposes is an absolute economic loss in the way of freight charges, labor and equipment. It does not profit the dealer and certainly represents a loss to the consumer.

Even at the risk of being charged with pleading for the trade in which we are engaged, those in the scrap iron business could make no more sincere and honest suggestion that would work the greatest good to the scrap consumer, than the one that all buying and selling of this commodity be conducted both by consumer and producer as far as possible entirely through large responsible dealers. They are not only agencies and sources of information, but properly organized, they should be watchful at all times of freight conditions. Because most producers want to realize immediate cash for their production of scrap, dealers have to act as bankers in many transactions. Trading through them should not be spasmodic but regular.

In consideration of the fact that the dealer will, under contract, deliver large tonnages of scrap to the consumer, the least such buyer can do is to refrain from acting as a competitor of the dealer in securing the supply needed for his orders. On the other hand, if manufacturers, railroads and other large producers would recognize the fact that it is the dealer who is seeking and providing a constant and steady outlet, and finding the most available markets at the time of production, and so encourage these dealers in their efforts in that direction by at least confining the disposition of their materials through these channels, we will have gone a long way towards solving many of the vexatious problems connected with the scrap iron business. No manufacturer here would feel it fair to use a jobber for the distribution of his products at times when it suits his convenience to do so, and at other times ignore him.

Such jobber or dealer could not long exist merely as an occasional incident to the trade.

If the changes in specifications as suggested by Mr. Lowry and qualified by Mr. Phillips were made definite and workable, they would go far towards a clearer understanding on the part of all concerned as to what is involved in the particular transaction. None of these suggestions, however, will have definite or lasting effect unless there is complete understanding and co-operation between the consumer, producer and the dealer as to the position and relation of each to the others.

Both speakers have implied a doubt as to the proper recognition of the scrap iron dealer by the steel trade. However, it must be concluded that the very courteous action on the part of the American Iron & Steel Institute in having these papers read and discussed by recognized dealers, is ample evidence of the regard of the entire trade.

I think it will be agreed, after considering the comprehensive papers on this interesting subject that, while the details and mechanics of the business can easily be worked out from time to time, it will only be by the use, and not the abuse, of the splendid facilities offered by the responsible organized scrap iron dealer, specializing in the handling and distribution that the most effective results will be obtained.

The Chairman (Mr. E. A. S. Clarke): The next gentleman to discuss these papers will be Mr. Albert Mann, Vice-President of the Illinois Central Railroad Company, Chicago, Ill.

Discussion by Albert C. Mann

Vice-President, Illinois Central Railroad Company, Chicago, Ill.

The subject, "Iron and Steel Scrap," so ably presented by Mr. Lowry, is an interesting and important one to the railroads; first, as purchasers and consumers

of approximately thirty per cent of the iron and steel production of this country, and second, as possibly the largest unit producers of scrap iron and steel outside of the steel industry itself. At this time, when we are hearing on all sides so much about conservation, it seems particularly appropriate that this subject should be made one for discussion by this Institute, whose membership includes consumers, dealers and producers of scrap iron.

The metallurgical considerations brought out by Mr. Lowry directly affect the purchaser of iron and steel, as he is interested in quality of product; but it is in the other phases of this scrap iron and steel subject that the producer of scrap is interested.

Scrap is a by-product of railroad operation and, after certain reclamation processes are completed, the accumulation must be so handled as to enable the railroad to economically market it. As the producer of steel strives to please his customer as to quality of product, so the railroad, as producer, must try to so grade and classify its scrap that it will satisfy its customer. As early as 1906, the railroads, through the organization of their storekeepers and purchasing agents, then known as the Railway Storekeepers Association, actively considered the need of a standard scrap classification and began a series of conferences with dealers and consumers with the result that the foundation was laid for the present scrap classification, which is now standard on practically all of the railroads and which forms the basis of purchase by the dealer or the consumer. This question of proper classification has been an active subject for discussion at the annual meetings of these Storekeepers and Purchasing Agents since that time and in 1921 the classification as it now stands was adopted.

Certain local conditions on some of the railroads make it necessary to depart occasionally from the standard gradings and often mixed grades of scrap will find

their way to the market, particularly from smaller railroads, where it is impractical to hold their scrap accumulation to permit the loading in carloads of individual grades. Whether a railroad could economically grade its scrap to meet a so-called percentage specification, as used by Mr. Lowry in one of his illustrations, is problematical, but I can see no reason why scrap could not be graded on a size and weight basis. A scrap producer naturally wants to get the greatest value out of his scrap grading and there is a growing demand for so called specialties in the scrap market, a tendency which the standard scrap classification bears out. The large quantity of such individual items as axles, journal boxes, couplers, knuckles, springs, etc., which appear on the scrap list today, indicate the demand for these specialties. Another problem, which seems to be ahead of us in the grading of scrap, may be brought about by the extended use of alloy steels which must in time find their way to the scrap pile and, dependent on the nature of the alloys, may require a separate grading before the scrap can be economically utilized by a steel producer.

Reference has been made to the manner in which railroads dispose of their scrap. A point has been made that very often a consumer of scrap will be allowed to bid on a railroad list, possibly in competition with a dealer, who already has on his books an order for the same grade of scrap from this particular consumer. Most of the large railroads send their scrap inquiries to an approved list of dealers and consumers. In my experience of nearly twenty years in the handling and supervising of sales of railroad scrap, I have found very little scrap sold direct to a consumer from the monthly or periodical scrap list and this in itself has proven to me that a necessary factor in the disposal of scrap is the scrap dealer or broker, who is always ready to buy scrap when a railroad list is presented. The railroad scrap list is a document containing a varied quantity and a varied quality of scrap of which no one item is suf-

ficiently large to attract the large consumer, who must of necessity buy large quantities of scrap in advance of his actual needs in order to meet his manufacturing conditions. Take the item of heavy melting steel; I do not believe there is enough of this grade of scrap accumulated in a year's time on any one railroad to accommodate a monthly order from a large mill. The railroad producer of scrap must sell as he accumulates, or as he can anticipate an accumulation, every few weeks or months. He, therefore, is dependent to a very large extent on the dealer for a constant market or clearing house for his scrap accumulation.

There is considerable room for more uniformity in the terms of sale or purchase of scrap iron. It would seem very desirable that certain special grades of scrap be handled on a net ton basis, but to make this standard practice throughout the country would involve many changes in the steel industry itself. Many products of the steel mills, particularly semi-finished products, are still sold on the gross ton basis; railroad freight rates are very largely on a gross ton basis; and unless all factors could be rearranged at one time, we could not avoid the inconvenience, which is noticeable today, due to the lack of standards in this respect.

It is apparent to me that considerable progress has been made over the past few years in giving to the scrap business the place it deserves in this iron and steel industry. Influences for good are at work and there is gradually being dispelled a great deal of the old suspicion, which was attached to a transaction involving scrap iron or steel. When all of the factors involved make honesty of purpose their first requisite in the transaction, the whole industry will benefit.

There is and should be no mystery about the scrap business and the right kind of publicity can have only beneficial results. Much has been done and can be done to stabilize the scrap industry by the various iron and steel trade papers, such as the "Iron Age" and the

"Iron Trade Review," etc., and these recognized trade authorities can be the means of keeping alive an active interest in the subject.

THE CHAIRMAN (Mr. E. A. S. Clarke): Further discussion will be by Mr. W. A. Maxwell, Jr., General Superintendent of the Indiana Harbor Plant of the Inland Steel Company, Indiana Harbor, Ind.

Discussion by W. A. MAXWELL, JR.

General Superintendent, Indiana Harbor Works, Inland Steel Company, Indiana Harbor, Ind.

In discussing Mr. Lowry's paper I have naturally assumed the consumers' viewpoint, wherein it affects production and metallurgy.

The prompt utilization of the marketable scrap produced in order to conserve natural resources is so evident that a discussion is unnecessary.

The ways and means of marketing the accumulated scrap, thereby providing for present day needs in an economical and metallurgical manner is of the utmost importance, and in that the consumer is most interested.

Scrap specifications deal only in generalities as pointed out by the author. Heavy melting and charging box size are merely terms having no true measure of value.

The factors regulating the use of scrap in the basic open-hearth process have been classified by the author under seven different headings, and will be here considered in the same order.

THE GRADE OF STEEL TO BE MADE

The contention that the acid process produces a superior grade of steel as compared with the basic process is true, but only true to the extent that an acid slag functions to a higher degree in producing a more thor-

oughly de-oxidized steel and not because the acid steel heat primarily demands a larger percentage of high grade scrap.

It is not always advantageous to use the maximum scrap charge in producing steel of good quality, not because the metalloids are not of the proper proportion but because of the wide difference in what constitutes heavy melting scrap.

Slow charging due to the character of the scrap results in "low melts" or "stickers," which in themselves are not detrimental to quality if the requisite precaution is taken to prevent over-oxidized steel. However, a series of stickers creates bottom trouble so that quality, production, furnace life and costs are seriously affected.

The Chemical Elements Required in the Charge

The metalloids contained in the pig iron are the true governing factors in the amount of scrap necessary to the charge. It would be possible to produce a greater tonnage, better quality and lower cost steel if the metalloids in the pig iron could be held within specified ranges. The ups and downs of silicon, not to mention carbon and sulphur, create conditions in open-hearth practice which prevent proper control. The production of pig iron containing the maximum percentage of carbon possible under normal operating conditions is always desirable.

Pig iron with silicon limits of 1.20 to 1.50% would reduce the pig iron requirements in the open-hearth charge as compared to limits of .75 to 1.00%, there being no decrease in carbon content up to 1.50% silicon, but the additional cost for coke at the blast furnace would undoubtedly offset any savings at the open-hearth department. Higher silicon iron within the limits mentioned is usually a hotter physical iron, which in itself constitutes a distinct benefit.

High manganese pig iron also tends to reduce the

iron charge and is a decided factor in the production of better quality steel.

High sulphur is not desirable at any time and is the one item pre-eminent which regulates the amount of scrap possible to charge, excluding the purely physical characteristics of the scrap.

The open-hearth operator would much prefer iron of known quality to scrap of doubtful quality, and more especially if the iron is molten. The author puts the case rather mildly when he states that the shipper little realizes the havoc he plays in shipping high sulphur material in with heavy melting scrap. The rejection of the car is not the remedy; the practice can and should be eliminated.

The use of carbonaceous materials in replacing pig iron is of doubtful value except in certain localities where the price differential between scrap and pig iron makes the high scrap charge extremely desirable.

Conversely, steel made from a very high iron charge is generally over-oxidized, iron loss is high, time per heat is lengthened, bottom delays create a decided loss in tonnage, furnace life is shortened, all of which raise the total cost per ton of ingots.

The addition of ferro-alloys in manufacturing the ordinary commercial grade of steel is virtually prohibitive due to price and furnace losses.

The presence of chromium, copper, nickel and other alloys in scrap is of no value except where scrap is purchased solely for the contained non-oxidizing elements, such as nickel and copper and where such purchase is made for purely economic reasons.

Certain percentages of nickel and copper in steel affect the working quality of the metal, so that it is most desirable to segregate these two grades of scrap; likewise certain percentages of chromium in scrap create furnace conditions which are neither beneficial to cost or quality, despite the ease of oxidation.

Plants producing large tonnages of nickel-chrome

steel have accumulated scrap piles of very considerable extent due to the inability to charge back the scrap as fast as produced because of the slag conditions occasioned by the chrome content.

The use of scrap or pig iron which necessitates an increased slag volume is not economical and is, therefore, undesirable.

Quality of Scrap

This item has a decided influence, being related directly to the metallurgical as well as productive capabilities of the furnace. To cite a concrete example—at the Inland Plant the percentage used of purchased so-called heavy melting scrap was 35% in March and 60% in September. The percentage of heavy bloom, billet and bar crops from the mills of this plant was 50% in March and 27% in September. The total tonnage lost in March chargeable to scrap delays was 2,023 tons and in September 4,270 tons. Production in March was 73,010 tons on a 9.7 furnace operation and in September was only 65,100 tons on a 10.9 furnace operation. It is entirely permissible to assume that had the quality of the scrap in September equaled that of March the September tonnage could have been attained with one less furnace operating.

Scrap of poor quality, where the consumer has a fair knowledge of the chemical elements could be handled in a more intelligent manner if the billing was indicative of the true character of the scrap.

Furnace Life

Either scrap or pig iron of doubtful quality is not conducive to a furnace life which is reflected by low cost per ton. Poor iron is worse than poor scrap.

Weight Per Cubic Foot

The adoption of a new specification to include weight per cubic foot is worthy of the most serious consider-

ation. A reduction in the item of scrap delays with an ensuing increase in production should offset the increased cost of preparing the scrap to secure greater weight per cubic foot. Delays in charging occasioned the loss of approximately 80,000 tons of steel in one year at one large steel plant because of the character of the scrap. Had this steel been compressed, delays could have been reduced from 50 to 75%. It is very evident that much scrap even now is being sold more or less on an analytical basis, although it so happens that these particular grades have great weight per cubic foot.

Ultimate Cost of the Metal in the Ingots

Local plant conditions necessarily govern costs. The supply and cost of pig iron and the cost of scrap are the determining factors. The extensive use of scrap in blast furnace practice was more or less of a war measure. Since then it has been a decided advantage within certain limits to continue the practice. The open-hearth department derives considerable benefit from this practice. Much of the scrap used is very undesirable for open-hearth charges. The metalloids in the iron are changed very little by scrap additions; production of iron is increased in direct proportion to the tonnage of scrap charged, so that the one point remaining, by far the most important, is what price can the blast furnace afford to pay for scrap. It is obvious that the price paid must conform to normal cost of production. Some authorities, generally speaking, say a differential of $4.00 to $5.00 per ton under the selling price of pig iron can be paid and still show a profit. The judicious charging of scrap in blast furnace practice should increase the output, decrease the cost of the iron to the open-hearth furnaces, thereby allowing lower ingot cost.

Mr. Kinney's figures, quoted by the author, are interesting in showing the possibilities of reducing costs by the use of better scrap but can only be used at this

time as a basis for an argument for better scrap specifications. Average practice today does not permit the substitution of purchased heavy melting scrap for molten pig iron in a normal operation. A decided slackening of operations allowing heavier charges of low-priced scrap permits lower cost. However, this is usually attendant when blast furnaces are being blown out and sufficient hot metal is not always available, so that the question becomes—cold iron or cold scrap.

Some plants reduce the pig iron charge up to a maximum of 10% by the substitution of dead burned lime for limestone. The cost per ton of ingots apparently justifies the practice, but there are certain metallurgical features incident to steel quality which require further study before a definite conclusion can be reached.

Scrap specifications of today are not advantageous to either the seller or the purchaser and decidedly less so to the ultimate consumer.

The objective point for any plant is the production of ingots at the lowest possible cost. Foundrymen in purchasing scrap realize that the "grading" is essential to lower costs.

The accumulation of large tonnages of bloom butts and crop ends in stock piles for use in making record tonnages when the demand for steel output is heavy is significant of the value of "grade" scrap to the larger producers.

The other problems to be met which the author has pointed out so clearly are not insolvable. Once solved, benefit would accrue to all.

The Chairman (Mr. E. A. S. Clarke): Gentlemen, that concludes the afternoon session. We have as guests this evening at the banquet Mr. Arthur Brisbane, Mr. Frank A. Munsey and Col. Maclean of Toronto, Canada, who are all newspaper men, and who are all expected to speak and I urge you to assemble promptly at 7 o'clock for the banquet in the Grand Ball Room.

EVENING SESSION

The evening session of the Institute was held in the Grand Ballroom of the Commodore. After dinner, President Gary called the meeting to order.

JUDGE GARY: Gentlemen, please remember your reputation for good order.

Ladies, uphold the men.

Those of you who are so disposed will please for a moment stand upon your feet in token of respect for the President of the United States.

(The assembled audience arose and sang the Star Spangled Banner.)

Ladies and gentlemen: During the exercises of to-day we have had the pleasure of listening to the addresses of some very distinguished men, who have placed us under obligations for their work, their study and their splendid presentation of the subjects assigned to them: they are at this table, and I will ask them to stand upon their feet so that you may look upon them, as an introduction to you personally; and I will ask you to pay tribute to them by rising after their names shall have been called by our secretary, Mr. Clarke.

(Mr. E. A. S. Clarke, Secretary of the Institute, read the names of the authors of papers delivered during the day, requesting these gentlemen to rise in their places. In response, the audience arose and applauded.)

And to the strangers within our household, if there be any such here, I should like to present to you as fine a body of men as ever honored any industry. Gentlemen of the Institute, stand up.

(The members of the Institute arose.)

This Institute at these banquets has been honored by some of the very distinguished men from this and

DINNER OF THE AMERICAN IRON AND STEEL INSTITUTE IN THE GRAND BALLROOM OF THE COMMODORE, NEW YORK, OCTOBER 24, 1924.

other countries, from a position as high as a King, as the Marshal of all the armies in the last Great War, of statesmen, diplomats and other lines of social and political and other activity.

Tonight we introduce a novelty, something a little better than we have ever had before. We shall have, outside of the gentleman who is always called upon to pronounce the benediction (laughter), three very distinguished men of the newspaper world (applause). They are distinguished not alone because they are great writers, great students, learned men, but because they, like all of those who belong to the Institute, have made their own way in the world in this land of great opportunity, men who started with no capital, with no outside assistance, who started like all of you to secure a position in the business world and who have become rich with money, which they earned, and who have become familiar with all the questions which so much interest men connected with the iron and steel industry, because it is a part of their business, their duty and their pleasure to become familiar with the things in which you are earning your money for your stockholders, and are devoting your time to securing and maintaining the prosperity of this country and therefore of benefit to the whole populace.

I wish first to introduce as a speaker a gentleman who started, I suppose, about where many of you men at this table, most of the men at this table, started, on the farm, and who step by step as the result of industry, fair dealing, honest conduct, has risen to the position where he owns, has owned large numbers of leading newspapers, including those which he has selected for retention.

The gentleman I refer to all of you know by reputation. Many of you perhaps have never before had the opportunity of meeting our friend, a friend of our country, Mr. Munsey. (Applause.)

Mr. Frank A. Munsey: Judge Gary, ladies and gentlemen: With Judge Gary's introduction, with a consciousness that I have no speech ready, and with the realization that if any audience in the world is entitled to a thoughtful, carefully prepared speech, it is this audience, the situation does not look very good to me.

It was only yesterday that Judge Gary said he would be glad if I would make some remarks, if I felt like doing so—five minutes or something like that. I said, "Well, if I think of anything to say, probably I can make a run of five minutes." Tonight I learned that the three speakers are to be Mr. Arthur Brisbane, Colonel Maclean and myself.

I wish I had a good speech for you tonight. I have the fancy that some time I should like to try to make a good speech to this wonderful body of men. Anyway, I am glad to be here. I am proud to be a guest of this great steel organization, an organization that represents the aristocracy of industry—represents it as no other organization of this country, no other organization in the whole world represents it.

I like to be here and to see fifteen hundred men who, through their own industry, their own intelligent application to their work, have risen to positions of importance, of great wealth, of great power, in this king of industries.

I love to see men who are workers. I love work myself; it is the greatest boon to man, the greatest incentive, the greatest steadying purpose, the greatest developing purpose in our lives. You have made your places through the working of the law of the survival of the fittest. There is not a man in this room, I am certain, who has his position because of any political influence, any other influence than that of his sheer ability, his knowledge of the job that has been assigned to him, his ambition always to go higher.

There is something about the steel industry that makes a kind of vigorous, strong man that you do not get

in the textile business, you do not get in the millinery business, you do not get behind the draper's counter. Your job gets into the fiber of the man, the strength of the thing with which you have to deal.

As a boy, there was nothing that interested me so much as a country blacksmith shop. Whenever I could find a little spare time, I would go to that blacksmith shop and work with the blacksmith. There was something thrilling to me about the power of that blacksmith, the power to mould, to hammer and to shape the iron on his anvil. I loved to see the sparks fly from his hammer. But there is more than that. I found a man there who had taken on something of the quality of the moulding and shaping power that he exercised over that iron and steel. I talked with him for hours at odd times, and it is a singular thing that one gets from a man like that, from a blacksmith, the evidences of better thought, of stronger characteristics, of wisdom, that you rarely find in other men of his grade in small towns.

I wish I had had the opportunity in those early days of association with men who were moulding steel and iron in the larger way, as all you men are doing. I loved to talk with older men; I loved to get their experience. I am a New Englander. I did not talk much myself. I prompted them to talk, and through them I learned much of life, much of human values.

I am and always have been, and I am certain that I always will be, a keen admirer of the man who does things, the man who makes a position for himself, the man who becomes a leader in his line. I look up to him today pretty much as I did years and years ago when I had never made any impression myself or shown any promise of doing so.

The things I have done myself, if I may be permitted to speak of myself in this way, seem trivial to me. They are simple to me. But the successes, the triumphs of other men who have dealt with hard problems, who have

begun life with no capital and who have risen to great heights—these are achievements that thrill me.

I suppose I have not used up more than three minutes of my five?

JUDGE GARY: About two minutes.

MR. MUNSEY: I suppose there is nothing you have been much more interested in, perhaps nothing you should be more interested in, than in our present political situation. It has a good many angles. It means more, this campaign, this situation, than any national campaign in many years. It means that a new political alignment is coming in. It means either that the great radical forces, numbering I should think in this country today something like 40 per cent. of our vote, who hitherto have had no organization of their own, are determined to build an organization of their own, or that they will come to possess the Democratic party and make it their organization.

I assume that most of the men in this gathering, being men of industry, men of affairs, are what we may call liberal conservatives. I cannot fancy that any of you are reactionary. You are men who recognize that the world moves, and you move with it. The reactionaries, the hard-boiled conservatives, or as they say in Great Britain, "the die-hards," I think are more dangerous in our political situation than the radical, because it is the hard-boiled conservative who makes socialists.

If 40 per cent. of our vote in this country is radical, I do not mean to say that La Follette will get any such vote, for he has no regular organization; but rather that the thinking attitude of 40 per cent. of our voters is radical, or liberal to radical.

If the radicals get possession of the Democratic party, taking that name as their name, thereby carrying all the conservatives or largely the conservatives of the South and the rest of the country with them through the force of party name, there will not be conservatives enough left in the country to have any important say in

the conduct of our National affairs in a good many years.

I view with real interest therefore the La Follette movement, if it does not go too far. I think it would be a calamity to have it go so far this year as to defeat Coolidge, for to my way of thinking Calvin Coolidge is the ablest administrator of the great affairs of this Nation that the country has ever had. (Applause).

I know that the president and officers of any one of the subsidiary companies of the United States Steel Corporation, or Mr. Schwab's corporation, or any other corporation, do not select a man for a given job, or for any great executive piece of work, because he makes a fine speech. They select him because of what they know he can do, and that is the way we ought to select the executive head of the business of this Government, which is the biggest business there is in all the world. (Applause).

Second to this country the biggest business is that of the British Government, not far behind but pretty well up at that. The third largest business lies between that of the French Government and the great corporation over which Judge Gary presides so brilliantly, so ably. (Applause).

To get a man like Calvin Coolidge in the White House at the head of that great executive job at this time, a man so wise, so sound in his common sense, a man who sees so clearly, reasons so clearly and has such splendid courage, is so utterly practical in every way, is the greatest piece of good luck. (Applause.) It was the accident of death that gave us this extraordinary man for this extraordinary occasion.

I think you will be glad to have me tell you who is going to win this election. I am confident that Mr. Coolidge will be reelected. (Applause).

While I recognize the danger of the situation beyond the Mississippi—these states have been getting more and more radical for a dozen years, and they are now very

radical—I think Mr. Coolidge, with the confidence the people have in him and in his leadership, would easily be able to swing these states in spite of their natural radicalism if it were not for the coalition of the Democrats with the radicals.

You see it works out this way. The Democratic party had not had anything very kind to say of this great city, with its Wall Street, its banking, manufacturing, commerce, merchandising—anything that is done in large measure in New York. To damn a city and the institutions of that city for forty years, and then reach down into the very heart of Wall Street for a candidate, was one of the amazing mistakes of the Democratic party. This is not reflecting on Mr. Davis. It is in no small measure because of this amazing mistake that the Democratic campaign has fallen flat, particularly in the states west of the Mississippi, where the forces of this strong old party are going over in what amounts to a coalition.

The situation then has come down to this, that we must elect Coolidge outright on the 4th of November or it is almost certain that Charles W. Bryan will be our next president—not a pleasant thought, I grant you; but we would better recognize the situation and do all we can to avoid that catastrophe.

With the exception of Kansas and possibly Wyoming there are none of the states west of the Mississippi that can be counted upon as sure for Coolidge. No more can they be counted upon as sure for La Follette. The only sure thing is that Mr. Davis will get none of them except perhaps Missouri and one or two of the three border states of Oklahoma, Arizona and New Mexico. California, Washington, and now Oregon, sandwiched in between them—all three of these states are very radical today: if we carry them it will be a piece of good luck.

One might talk a long time on this political situation; but I think perhaps my five minutes are up. The other speakers are waiting for their turn.

I thank you for the privilege of being here tonight.

I am proud to be your guest. I hope you will ask me again. (Applause).

JUDGE GARY: If the conservatives will do everything within their power and influence to help everyone to become possessed of a home and property the kind of radicalism that we might fear will go glimmering (applause) and we will do what we can in that direction.

Colonel Maclean comes from Canada. You know where that is; but you have never seen the line between Canada and the United States (applause), and you will never find it, because their interests are ours, and our interests are theirs; because the friendship between the two places will never be diminished.

Colonel Maclean is the owner of several newspapers and magazines. Like Mr. Munsey, he talks through his publications all the time. I have never heard him speak, but I have read much that he has written. From his writings I know what is in his head and in his heart, and I am very glad that he has been so prosperous, so friendly, so influential in the newspaper world, in the reading public and in every way, in increasing friendly feeling between our two countries.

It is a great pleasure to have Colonel Maclean here tonight and to have opportunity to hear him speak. With great pleasure I present him to you. (Applause.)

LT.-COLONEL J. B. MACLEAN: When Mr. Hobson, Chairman of the Steel Company of Canada, came to me late this afternoon, and said that Judge Gary expected me to speak tonight he added, "The Judge told me to ask you tactfully to endeavor to limit your address to an hour and a half," I said, "For Heaven's sake, Bob, what can I talk about?" Mr. Hobson replied, "If you take my advice you will talk *about* ten minutes. But I know you won't take it. You never do."

I finally agreed, with much hesitation and many misgivings, for I could not see just what message I could bring you, what information I could give you that would

interest the great leaders of the greatest industry in the greatest industrial country in the world.

But what was I to speak about? One inspiration or line of thought came to me. The day before yesterday I was lunching and gossiping over the general political and business situation with a great friend of mine who is one of the outstanding financiers in Canada. I happened to say that I was looking forward with great interest to Judge Gary's annual review of the situation this week. My friend asked me, "What rôle exactly does the Judge fill in the great Steel Corporation?" I said, "I cannot answer you in detail, but I can say this. His most important work—a work he has done with far-reaching success—has consisted, first of all, in getting his associates to understand that they are trustees of a great trust; that their first duty was to render service—willing service and honest service—to the public; and next, he has succeeded by precept, by example, and by practice backed up by the policy of his great company in attracting public sympathy and confidence to the Steel Corporation and to the steel industry generally and to all big business and big finance of the United States—as a by-product."

You are leading the world in practically every phase of the many phases of production; I need not enumerate them. Any one of them is a great inspiration and achievement in itself, but it seems to me, speaking with experience and some knowledge, the greatest and most difficult of your accomplishments is one that seems to have passed unnoticed. It is that in working up to and since the attainment of these leaderships you have been fair, even generous, with your customers and your workers, and you have never exacted the full limit of profit as you could so easily have. The result is that you have a great public sentiment, public sympathy and intelligent opinion with you.

I wonder if you realize what that means, not only to the steel industry, but to all business in the United

States? This leadership and your tremendous aggregations of capital made you extremely vulnerable to attacks from envious masses inspired by agitators. It seems to us in Canada, looking at you from the outside, that you have been sitting on a volcano with, first, your enormous populace of foreign birth or parentage (and we know a great deal about that in Canada), not yet made over into the splendid American citizens so many of them are bound to become; all of these people subject to misunderstanding; and, next, and perhaps more dangerous still in these days of high wages and high living, with your intelligentia (if I may use that term to cover your clergy, preachers, professors, teachers, journalists and other educated leaders.) While labor and capital have been more prosperous than ever before, the incomes of the intelligentia who lead—and often mislead—public opinion, have not grown in proportion. They have had a mighty hard row to hoe. The agitators have told them the injustices and the exactions of capital are the cause. Yet these people have appreciated your desire to be just and fair, and have refused to be stampeded. Instead, public sentiment has backed your Government in doing anything within reason to assist you in marketing your products and will permit no intentional injustice to your interests from designing politicians.

What would have happened in this country at this time had you not been so wisely led?

In Canada—now here is where you see the difference—business, manufacturing, public utilities and banking, conservatively and splendidly led for two generations, were very popular, but during the last ten years we have not been so wisely led, not led as you have been here, and these interests have become unpopular, with the natural result that wasteful and expensive public ownership has become a religion in some provinces and all industry is being subjected to repressive legislation and excessive taxation.

Sound banking, national banking has been put in

danger. We narrowly escaped at the last Session of Parliament, the passing of regulations affecting banking that would have put our finances in a very unsound position; I do not know just where it would have led. The situation was not saved until the head of one of our banks, speaking before the Banking Committee of the House of Commons, took the same attitude as Judge Gary.

Because of this situation, when every other important country in the world—sixty-six of them, I think—have been increasing their customs tariff, the Government of Canada has been compelled under pressure of inflamed and misled public opinion to reduce its tariff five times in five years, and still more reductions are demanded and will come next year: all this because we have not been led as Judge Gary and the American Iron and Steel Institute have led the steel industry and set the example to all big business in the United States.

Canadians will have a greater income from production this year than in any normal year in history, but because of a wrong attitude towards industry and business there is a feeling of uncertainty, necessarily a feeling of uncertainty. Happily, the situation has been recognized and in the banking attitude toward the public there has been a marked change recently.

With all these experiences, it would seem to me that the public policy of the steel industry so well expressed by your Chairman in his great address this morning, should be the policy of all industry in Canada and the United States, when he said, in effect, that the duty of capital to each problem as it arose was to take the fair and equitable view and to follow that view fearlessly and without sacrifice of any moral principle. (Applause.) Judge Gary expressed it much better than I am able to do from memory. In concluding I want to say that during dinner I spoke to Colonel Cantley of the British Empire Steel Company who is here, and told him the line of thought I proposed to take and asked him if he thought

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I was right. He said "Yes," and remarked emphatically that the wise and fair direction of the steel industry in the United States, he was confident, was the greatest stabilizer of the political as well as the business and financial situation in this country.

I thank you for your kindness in listening. Had I known that I was to sit next my old friend Mr. Schwab, I could have given you perhaps a more interesting and more lengthy speech. Mr. Schwab has the table here covered with notes. All I needed to do was to take the notes that he has worked out over on my side. I shall have to leave those to him. (Laughter.)

Mr. Chairman and Gentlemen, I thank you for your courtesy and generosity. (Applause.)

JUDGE GARY: Do you read the first column in the "American" every morning? Those of you who do not had better commence. It goes all over this country. It is read by many millions of people every day. It is spicy, sharp, pointed and profound.

You will get more information there in regard to the principal occurrences of the day than you can get anywhere else in the same space.

Mr. Brisbane is a wonderful influence to this country. (Applause.) He receives the biggest salary of any man in the newspaper world. He started poor and has become rich. Within a short time he will commence the erection of two very large structures in this city. You men who sell steel for that purpose had better be considering Arthur Brisbane: you will treat him right, or offer to treat him right; if you do not, the United States Steel Corporation will try to do so. Fair warning.

Within a stone's throw almost of this building Mr. Brisbane will soon commence the erection of a large building that will go thirty stories high. But better and bigger than all that is what is contained in his head, not much bigger than yours or mine: a little balder on

the outside than some of yours, but not at all bald on the inside. (Laughter).

Mr. Brisbane has reached the position where he has been compelled by the force of intellect to know what you gentlemen are doing and to appreciate the success which you have reached. It is a great pleasure for him to be here; it is a great pleasure for us. Intimate in his relations with Mr. Munsey and the other newspaper men of this country, he is less intimate with men engaged in your lines of business, but he knows more about you and what you are doing than you think.

We are afraid of newspapers—no, we are afraid of ourselves lest the newspapers expose us when we are wrong; and it is a great thing, because we are influenced to try and do the right thing.

We never object to criticism if it is honestly made, and those of us who act wisely will read or listen to criticism and endeavor to ascertain ourselves whether or not it is deserved and, if it is deserved, we will reform our methods. As for me, I like the newspapers; they have treated us better than we have deserved—generally—speaking now particularly of myself, and it is for that reason that I always like to see them, and I am especially delighted to have these distinguished gentlemen here this evening.

It is now my very great pleasure to introduce Mr. Arthur Brisbane. (Applause).

Mr. Arthur Brisbane: Judge Gary, ladies and gentlemen: You have a mixed collection of newspaper men here. Mr. Munsey and Mr. Maclean are owners; I am a poor employee. Unlike them, I cannot afford to come to such a meeting as this without a carefully prepared speech, and I have it here on this bill of fare. (Laughter). I had prepared a magnificent beginning. I was going to say that a newspaper man feels timid coming before you, for you erect columns of iron and we only erect columns of words; and then after you were proud of yourselves I was going to say, "However, the right

kind of word, for instance the eleven words in the definition of evolution, written by Newton, will outlast all your steel and all your money and your power. And Munsey and Maclean and I write hundreds of thousands of such words every year." (Laughter).

Now, gentlemen, that speech had a peroration as good as the beginning, but it has been spoiled by things that have been said. I have got to attend to those things and by the time I have attended to them it will be too late for any regular speech.

On behalf of Mr. Munsey and myself I resent Mr. Maclean's statement that we are downtrodden intelligentia. Mr. Munsey and I between us are worth at least fifty millions of dollars (laughter): of that amount I have one hundred thousand (laughter), and Munsey has got the balance. (Laughter).

I have seen both Judge Gary and Mr. Schwab about supplying the steel for my building at 57th Street and Park Avenue, and I have learned from our Wall Street reporter that they have been seen together several times since (laughter); and while I know that there is no such thing as price fixing I suspect that one of them will offer me steel fabricated at $78 a ton f.o.b. Jersey City and the other will say, "That is not a very good bargain, I am giving you the steel fabricated, with one coat of nice red paint, $78 a ton, f.o.b. Hoboken." (Laughter).

Our friend Mr. Munsey, whom I knew when his hair was made up of golden ringlets, says you people are the result of the survival of the fittest. You are to some extent; but there is a book written by a learned Russian named Kropotkin, "Mutual Aid as a Factor in Evolution," that Frank Munsey should read. Darwin emphasizes the survival of the fittest, teaching that the powerful live and the weak die out; but Kropotkin much more truly tells you that the powerful die if they do not help each other and the weak survive if they do help each other.

Suppose you had been on Long Island a thousand years before Columbus came and had seen the deer on

those plains and wolves coming out of the forest to eat the deer, and somebody had asked you, "How long will there be any wolves in these woods?" You would have said, "Why, of course there will be wolves here as long as there are any deer for them to eat." But not at all. There are deer in Long Island today, so many of them that they are a nuisance occasionally, and there are no more wolves, for this reason. Where you have twenty-five deer grazing, every deer has fifty eyes and fifty ears in his service to warn and protect him, whereas the wolf comes, kills his prey and slinks off. If one wolf has a broken leg and falls, the other wolves eat that brother; so, the wolves vanish and the deer, helping each other, survive.

So it is in business. The survival of the fittest may still go between nations, with their poison gas and their shrapnel and their flying machines, but between business men and between our states fortunately we have passed from the stage of struggle and the survival of the fittest to that of mutual aid as a factor in evolution. (Applause).

Under modern conditions it is foolish to discourage great industrial and commercial enterprises, to discourage men capable of building organizations that can compete with foreign international organizations.

It is encouraging to learn that out of a world capacity of seventy millions of tons of steel a year this country has fifty millions of tons capacity and has actually produced forty-four million tons.

Nobody has the faintest idea of what this country is going to do. A text that every man, big or little, should have on his desk, is:

"It hath not yet been shown what we shall be."

We are well placed. We have a country well worth preserving. And, gentlemen, if I was sufficiently foolish to waste your time with a serious speech, which the Lord and the Judge forbid, I would ask you to think as steel makers about the problem of greatest importance to the United States—the only problem, because, if there is a

possibility of your factory burning down, everything else is unimportant—that problem in this country is the problem of a proper fighting air fleet for national defense.

You men make the steel, flying machines will be made of steel. The old story will not be repeated, when they laughed at the idea of a steel ship, and when the experienced men who made wooden ships said the steel ship would sink, and, in the second place, nobody would be foolish enough to make it. You know that flying machines are going to be made of steel, you know that there are going to be hundreds of thousands of them—and you ought now to plan for making them.

England is very polite to France for the reason that France has two thousand fighting flying machines in her first line and two thousand in her reserve. She could declare war on England at 8 o'clock in the morning and at noon there would be no London, Liverpool or Manchester left.

Japan is a nation that will always remain friendly, I trust. And I know she will always remain friendly if we have enough flying machines (laughter and applause); Japan has seventeen factories working night and day producing flying machines, and she is not producing them to tease China.

There are no more oceans; there was a time when we had a three thousand mile ocean on one side and a seven thousand mile ocean on the other. When Napoleon was seeking to cross the English Channel, he got word that an American wanted to see him and said, "Tell that American I can give him just two minutes:" the American came in and Napoleon gave him two minutes. That American was Fulton. He could have told him how to get across the Channel without waiting for wind and across the ocean without sails.

A big gas bag came across the other day at its leisure. Machines that are flying in Europe today can cross the Atlantic Ocean in ten hours; they could start in the morning and be here for dinner; machines can cross the

Pacific, it is merely a question of fuel supply. If anybody says, "Oh, they could not carry enough gas to cross the Pacific," just remember that when the steamship was first invented the wise men said, "Even if a steamship could go across the ocean, no boat could be built to carry enough coal to make enough steam to take it across the ocean." But they do carry enough coal and they do go across.

People in Paris thought they were safe until Big Bertha began dropping bombs from a distance of 70 miles.

We have along our ocean the most ridiculous things in the world, whoever relies on them is a babe in arms; we have coast defense guns that can fire 35 miles. Does anybody suppose that an enemy is going to come within thirty-five miles to be shot at, when a flying machine can go 500 miles an hour, high in the air, out of sight?

You have things worth keeping, you may not have anything if this country does not interest itself, not in a fighting fleet as big as the French fleet, not in having a fighting fleet as big as Great Britain's, but in having a fighting fleet twice as big as that of any nation of the world.

If we cannot afford it, then we cannot afford the very large fortunes indicated in the tax returns, beginning with Jack Dempsey, $90,000. (Laughter and applause).

Judge Gary: Delightful companion, loyal friend, supremely successful in anything he undertakes, optimist, wit, orator, prince of good fellows: what more need be said of Charles M. Schwab, who will pronounce the benediction. (Applause).

Mr. Charles M. Schwab: Judge Gary, ladies and gentlemen: It was not my good fortune to have received your accustomed welcome at the last meeting, but it is all the more appreciated tonight.

It seems with each advancing year that the welcome of one's old friends sounds sweeter and dearer to the ear and heart, however it may be expressed.

I have recently been to Homestead, Homer Williams'

town and my town of friendships in the early days of the steel industry. The welcome extended me there by my old associates and the working men was very dear to my heart—one especially, Jimmie Dugan, who was a good heater in the mills, in days gone by. He was growing older, and, having a couple of sons prosperous, finally decided he would go into business. He established an undertaking business; he has a window, as these undertakers have, and in this window I saw as I rode along the streets, my portrait, decorated with flags and flowers, and underneath the portrait, the words "Welcome, Charley." (Laughter).

I knew that Jimmie's heart was all right. I knew that the welcome was just as sincere and just as dear and just as appreciative as it has been from you, my friends in the iron and steel industry.

Now about Arthur Brisbane. He is a very dear and a very old friend of mine. I have never hesitated to speak either critically or in a jocular way of any of my friends at these dinners heretofore; but I must confess I am afraid to say anything about him to-night. You know it is strange how great minds that influence public opinion and are important in the affairs of the country run in the same channels. We have both written our speeches on menu cards. (Laughter).

I have been wondering. When the Judge said that Arthur Brisbane received the greatest salary of any man in the newspaper business I felt relieved, because he added "in the newspaper business," for great as is his salary it would seem to me, if I read the tax returns correctly this morning of Judge Gary and Douglas Fairbanks, there are other people receiving greater salaries even than Arthur Brisbane. (Laughter).

I have also been wondering with reference to this building that Arthur Brisbane is going to build, if he has all the money that is necessary to erect such a great structure here in New York, what the hell he wants with the building. (Laughter).

You know Judge Gary and I did confer about this, though we had no idea that Brisbane knew about it (laughter); but the Judge, with his usual sagacity, has placed Arthur Brisbane next to him at dinner tonight (laughter), and has taken an unfair advantage of me. Therefore I want to say that however attractive Judge Gary's prices may be (Grace told me to say this), if Arthur Brisbane wants the steel for that building for nothing he can have it from the Bethlehem Steel Company. Of course, when Brisbane goes to buy the steel from Grace, Grace will probably have forgotten that conversation. (Laughter).

Well, at any rate, Mr. Brisbane is a true friend of all the people in the iron and steel business. I have talked many times to him about its intricacies and its difficulties. He is a great man, and he has done much to influence in the right direction opinions in this country, and I am sure he will treat with the proper spirit and think of in the proper spirit the few remarks we have made. That is always done in terms of friendship, friendship that has existed over a long, long period.

Now as to Frank Munsey, there is just one difference between Frank Munsey and me. Frank started on a farm and I ended up on a farm. (Laughter). Really, I don't know who has done the progressing, whether Frank, who started on a farm and progressed to a great newspaper owner, has made the greater advance, or I, who started in manufacturing and finally progressed to be a farmer. Now, one may be a great man from the standpoint of riches and accumulation—this forty-nine million nine hundred thousand that Mr. Brisbane speaks of—but I doubt if Frank Munsey has ever learned the true appreciation of raising fine cattle and horses and all that sort of thing that I have recently up on the farm. I coaxed Frank to the big Fair that we held in Loretto. Frank said he did not like the country because he could not sleep at night. I asked "What is the trouble, Frank?" He replied, "The roosters crow in the morning." I said,

"Frank, that is only one minute." "Yes, it is," he responded, "but it is waiting for the damn rooster to crow that troubles one." (Laughter).

Great man, great writer, great everything that he is, still he has not learned yet, as far as I can find out, that true bucolic pleasure of lying abed in the morning and having your breakfast brought up, then sauntering out and looking over your cattle, horses, cows, pigs and sheep —and then having the pleasure of it all destroyed when the month's bills come in, and you have to sign checks to pay for everything. (Laughter). Frank could do that, if he wanted to. I hope that he will progress as I have progressed, in the real enjoyment of life, and that he will give up the idea of directing the policies of political parties and everything in the United States for the enjoyment of the things that Judge Gary as a farmer and I as a farmer, old steel men of the past, now enjoy. I do not rate the Judge as a farmer. You know, I told you about the picture he had taken with one of his fancy cows. Well, that showed the Judge up pretty badly as a farmer; but still he has at last settled down to one thing. He told me confidentially today that, having tried every branch of farming, he had finally decided that the best crop to raise on Long Island was turnips, because they were useful to feed the cattle and the horses and commanded a better market here than most any other vegetable product.

Well, the Judge has turned up some interesting situations in the iron and steel industry, but always to the benefit of the industry. One of the things I expected to do here tonight— it is always a pleasure to do it— was to say a few words in commendation of Judge Gary. But I want to tell you a story first of Mr. Carnegie in his older days, when he used to indulge in reminiscences. He loved to talk about the past, and the things that happened in the years gone by grew greater and greater in each successive year of relation; unfortunately for me he would always prove the truth of his stories by me; he

would turn to me after telling a story of the wildest description and say "Is that not so, Charley?" and I would of course say "Yes, that is surely right." But one day, getting tangled, realizing that he had made a mistake, he turned quickly and said, "Well, Charley, we understand each other anyway." (Laughter).

So Judge Gary and I, all the Iron and Steel Institute people, after these twenty odd years of association, have learned to understand each other.

May the policies of this great organization and may its spirit in the future as in the past for many years to come be directed by our talented, genial, splendid President: God bless Judge Gary and spare him many years to help us in the upbuilding of this great industry to which he has contributed so much in the past. (Applause).

May the Institute grow in numbers, as it will grow in good fellowship; may we find that great joy and satisfaction in duties well accomplished; may your business be prosperous, may your hearts be light, may your pocketbooks be heavy, may you still find the same genial companionship and association in these annual meetings that we have found in years gone by; may you be content with the work which is to come to you; may Frank Munsey's prophecies politically be true and truly realized (applause); may we have prosperity, may we have happiness, may we always have such delightful gatherings as tonight; may we have Judge Gary for many years to come. God bless you all. (Rising applause).

JUDGE GARY: Good night.

PARTICIPANTS MAY MEETING

(*Guests)

Abbe, Albert N.
*Abbott, R. B.
Abbott, W. H.
Abel, A. E.
*Aborn, C. N.
Adams, F.
*Adams, J. R.
*Addams, Homer
Agnew, John D.
Ahlbrandt, G. F.
Akin, Thomas R.
Alder, T. P.
*Alexander, L. A.
Allen, John N
Alley, James C
Allyn, A. W.
*Ames, Hobart
*Amis, F. W. T.
Anderson, Brooke
*Anderson, George L.
Anderson, Nils
*Andrews, F. D.
Andrews, J. I.
Armstrong, Victor C.
Arnold, L.
*Arpe, W. W.
Arthur, T. A.
*Ashey, Harold C.
*Ashley, James L.
*Ashy, Harold
Atkinson, Lloyd H.
Atwater, C. G.
*Austin, F. G.
Austin, H. L.
Austin, W. H. A.

Baackes, F.
*Bachelder, W. F.
Bacon, Charles C.
Badlam, Stephen
*Bahr, H. T.
Baily, R. M.
Baily, T. F.
*Baizley, John
*Baker, A. C.
Baker, Hugh J.
Baker, M. G.
*Baker, P. R.
Bakewell, D. C.
Baldwin, H. G.
Baldwin, R. L.
Balsinger, W. R.
*Bancker, W. F.
*Bandler, William A.
Banks, A. F.
Barashick, Aaron
*Barbour, James W.
*Barnum, G. S.
*Barnum, J. P.
Barrett, J. C.
Barrows, W. A., Jr.
Batchelor, E. D.
Batteiger, R. L.
*Bauer, F. W.
*Baylis, J. K.
Beale, Horace A., Jr.
*Beale, Phelan
*Becher, E.
*Beck, E. A.
*Becker, H.
Becker, Joseph
*Becker, Luther
*Becket, F. M.
Beeson, C. E.
*Belford, J. Frank
Bell, G. Graham
*Benedict, E. L.
*Bennett, C. F.
Bennett, D. P.
Bennett, W. H.
*Bensel, Arlington
*Bent, Arthur
Bent, Quincy
Bergquist, J. G.
Bertie, C. E.
*Besom, Thomas
*Best, C. M.
Beyer, Lucius H.
*Biftline, Edmund D.
Biggert, C. F.
*Bindley, Albion
*Binnex, F. K.
Birney, E. H.
*Bishop, Harry W.
*Black, John B.
Blackwell, Harry E.
Blakeley, G. H.
Blauvelt, W. H.
*Blazo, R. E.
Block, P. D.
Blowers, W. B.
*Bode, J. H.
*Boeker, O. F. G.
*Boley, E. W., Jr.
Boley, Ernst
*Bolton, J. C.
Bonner, James B.
Booth, Lloyd
Bothwell, Walter J.
Bourne, H. K.
*Bovaird, M.
*Bower, W. C.
*Bowlan, Frederic J.
*Boyd, James
*Bradin, James
Bradley, Carl D.
*Bradley, Francis
Bradley, H. S.
Braid, A. F.
Brainard, J. W.
*Brandeis, Eugene
*Bransome, E. D.
Brassert, Hermann A.
*Breed, R. E.
*Breitung, Max
*Bretland, C. W.
Brion, A. E.
*Brodhead, Frank M.
Brokenshire, E. L.
*Brooke, Frank W.
Brooke, George, 3rd
*Brooke, Robert C.
Brooks, C. K.
Brotherton, F. C.
*Brower, Roy L.
Brown, Alexander C.
Brown, Charles M.
*Brown, Charles R.
Brown, Frank L.
*Brown, Harold B.
Brown, John C.
*Brown, P. D.
*Brown, William A.
Browne, deCourcy
*Browning, R. R.
Brunke, F. C.
*Bryan, J. H.
*Buchanan, W. E.
Buck, C. A.
Budd, R. B.
Buell, James A.
Buffington, E. J.
*Bullard, A. H.
Burton, Carroll
*Bush, A. R.
Bush, D. Fairfax
Butler, Gilbert
*Byers, Wiley L.

*Calderon, A. A.
*Calkins, Loring G.
Campbell, James A.
*Campbell, N. A.
*Campbell, William
*Campion, J. H.
*Cannon, R. A.
*Carringer, J. R.
*Carroll, William J.
Carruthers, J. G.
Carse, David B.
*Carse, Donald R.
Carse, John B.
Carson, George C., Jr.
Carter, Emmett B.
*Carter, G. O.
Casey, Francis Y.
*Casterton, J. W.
Cebrat, Paul
*Cederquist, Milton O.
Chamberlain, A. H.
*Chambers, C. E.
*Chandler, H. T.
*Chandler, John
*Chaney, C. C.
Chapin, F. H.
*Chapman, E. J.
*Charles, J. S.
Charls, G. H.
Cherry, C. A.
*Chisholm, C. G.
Christ, E. W.
Christian, A. W.
Church, Edwin S.
*Churchill, Thomas W.
Clack, C. T.
Clarage, Arthur T.
Clark, Eugene B.
*Clark, E. F.
Clark, F. E.
Clark, J. B., Jr.
*Clark, Kenneth
*Clark, P. R.
Clark, R. W.
*Claussen, J. A.
Claypool, George L.
*Clebourne, E. B.
*Clements, B. A.
Clingerman, W. H.
Close, C. L.
Cluff, C. C.
Clyde, William G.
*Coburn, F. Ward
*Cochran, Joseph W.
*Cohen, F. C.
Colbert, C. F., Jr.
*Colby, H.
Colladay, F. H.
*Collins, C. I.
Collins, E. C.
Collord, George L.
*Comstock, George
*Comstock, Jack R.
*Cone, Edwin F.
Connell, Frederick
Connors, George W.
Cook, H. H.
Coons, Perry T.
Cooper, S. G.
*Corbett, E. B.
Corbett, W. T.
Corey, A. A., Jr.
Cornelius, Henry R.
Cornelius, William A.
Cort, Stewart J.
*Corwin, Frank
*Cosgrove, William H.
*Cotsifas, D. D.
*Cotter, Arundel
*Cotter, W. E.
Cox, John L.
*Craig, Horatio
*Craine, C. P.
*Craver, H. W.
Crawford, George G.
Crewe, L. C.
Crockard, Frank H.
Crocker, George A., Jr.
*Cross, L. W.
Crotsly, A. W.
Crowley, Dennis, Jr.
*Cruso, C. A.
Cueman, J. Bently
*Culbert, Isaac T.
*Cunningham, W. H.
*Curley, J. F.
*Curtis, F. Kingsbury
Cutler, W. C.

*Dalton, A. D.
Dalton, H. G.
Damerel, George
*Dana, R. H.
Danforth, Arthur E.
Danforth, George L., Jr.
*Danner, George H.
Darlington, Thomas
*Darwin, George A.
Davey, John
Davey, Samuel
Davey, W. H.
*Davidson, L. R.
Davies, Albert P.
Davies, George C.
*Davies, W. R.
Davis, Edward L.
*Davis, H. H.
Davis, Henry J.
Davis, S. A.
Davis, W. P.
*Davis, Walter A.
Deetrick, J. W.
*deHoll, H. R.
DeLano, S. P.
Dell, Charles S.
*Deming, J. C.
*Denio, G. L.
Dennis, M. S.
*Denyven, George W.
*Desmond, L. E.
Dette, William
*Deutchbein, H.
Deutsch, Lee
Devens, H. F.
Devens, Richard
*Dewey, Victor F.
*Dice, A. T., Jr.
Dickerson, A. V.
*Dickey, W. C.
*Dickinson, H. B.
*Dickson, H. C.
Diehl, A. N.
Dillon, Sydney
Dimmick, Fred D.
Dinkey, A. C.
*Dirkes, Frederick A.
*Doak, Samuel E.
*Doane, George B.
*Doane, George B., Jr.
*Doane, J. P.
*Doke, George E.
Donner, Joseph W.
Donner, Robert
Donner, W. H.
Dorman, A. D.
*Doty, John W.
*Dow, H. G.
*Dow, James K.
Dowling, Eugene
*Downey, A. C.
Downey, James A.
*Doyle, M. A.
Driver, F. L., Jr.
Duane, James, Jr.
Dubois, H. C.
*Duemler, F.
*Duff, J. R.
*Duffner, Carl A.
*Dunlavy, C. A.
*Dunning, E. E.
Dunsford, J. R.

*Earp, C. H.
Easton, H. M.
*Edgcomb, H. L.
*Edgerley, W. H.
*Edward, D. B.
*Edwards, C. S.
Edwards, E. T.
Edwards, Gordon L.
Egbert, Justus
*Elder, F. C.
*Eller, H. D.

Ellicott, C. R.
Elliott, C. H.
Ellis, E. E.
Ellis, J. M.
Emery, R. Edson
Endicott, G.
*English, E. F.
*Enscoe, G. R.
Eppelsheimer, D.
Estep, Frank L.
*Evans, Charles T.
*Evans, T. R.
*Evans, Thomas W.
Exstein, Henry L.
Eynon, David L.
Eynon, D. L.

Farrell, James A.
Farrell, J. J.
*Farrell, W. K.
*Faulkner, George
*Fay, C. F.
*Feeney, O. V.
*Fell, J. P.
*Fernandini, E. E.
Field, Herbert E.
Filbert, W. J.
*Fillius, Y. F.
Finch, J. H.
*Findley, M. F.
*Finger, F. N.
Fink, George R.
Fisher, Charles A.
Fisher, P. L.
Fitch, J. H., Jr.
Fitch, W. H.
*Fitzsimons, Robert
*Flannery, Walter
*Fletcher, John
Fletcher, John F.
*Flint, Charles R.
Flintermann, R. F.
Floersheim, Berthold
Flora, A. N.
*Foley, Frank J.
*Forbes, G. A.
Forbes, W. A.
*Forcier, C. W.
Forster, C. H.
*Foster, A. M.
*Foster, David G.
Foster, Edwin C.
*Foster, R. L.
Foster, T. J.
Fowler, A. A.
Fowler, Oswald
*Fox, Gordon
*Fox, Walter
Francis, Lewis W.
Franz, William C.
*Franz, W. C.

Fraser, J. S.
*Frazier, J. W.
*Frevert, H. L.
*Frey, E. C.
Freyn, H. J.
*Friedlaender, E.
Fries, J. E.
*Frisbie, Mr.
Frost, Frank R.
Fuller, F. D.
Fuller, H. Harrison
*Fulton, J. S.
*Furness, Radclyffe

Gaffney, A. T.
Galbraith, A. T.
*Gallagher, J. F.
*Gallagher, J. W.
*Gardinor, Clifford R.
*Garford, A. L.
*Garrett, Frank
*Garrett, H. S.
Garrity, John E.
Gary, Elbert H.
Gathmann, Emil
*Gathmann, Mark
Gault, J. W.
Geddis, Robert
Geissmann, Theodore
Gellert, N. H.
*George, H. S.
Gerry, Roland
Gewecke, J. H.
Gibbs, E. Everett
*Gibson, G. R.
Gillespie, J. M.
*Gilligan, Walter
Gillispie, R. W.
*Gilmore, Robert
Girdler, T. M.
Gittins, Arthur W.
Glass, Alex
Glass, Andrew
Gleason, W. P.
*Glessner, A. W.
*Goedecke, M.
*Gogay, Henry
*Goldsmith, A. P.
*Goldsmith, B. J.
*Gomber, W. J.
Gordon, F. H.
*Gordon, George C.
*Gosselin, L. C.
Grace, E. G.
Graham, Charles J.
*Graham, W. F.
Granger, L. D.
*Graves, Bert
*Gray, J. J.
Grayson, S. A.
Green, W. McK.
Greenawalt, John E.
*Greene, Edgar T.
*Greist, A. O.
Gresham, W. B.
Griffin, J. C.
*Griffith, R. E.
*Griffiths, E. A.
Grose, James H.
Gross, John M.
Grugan, Justice F.
*Grundy, George H.
Guba, Philip M.
*Guttzeit, Charles W.

Hackett, S. E.
Hadly, Charles O.
Hadly, R. J.
*Hager, T. W.
Haggerty, Frank L.
Haggerty, H. W.
*Haldeman, Mr.
*Hall, E. P.
*Hall, Harry T.
*Hall, Thomas H., Jr.
Hallman, Harry F.
Halstead, Kenneth B.
*Ham, T. C.
*Hamilton, R. E.
*Hammond, A. J.
Hammond, James H.
*Hammond, J. Sidney
Hancock, W. W.
*Hand, C. H.
*Hansell, N. V.
*Harbaugh, Donald
*Harding, Harvey
*Hardy, C. K.
Haring, Willard S.
Harris, Chapin E.
Harris, Emrys
*Harris, T. A.
*Harris, W. J.
Harrison, E. W.
Harrison, J. L.
*Hart, M. S.
Harvey, A. F.
Hatfield, Joshua A.
Havemeyer, John F.
*Hawkes, Albert W.
*Hayden, E. J.
Hayes, Earl M.
*Hays, G. O.
Hays, W. C.
Hazen, J. F.
Hazlett, Adam J.
Hazlewood, Stuart
*Healy, R. F.
Hearne, William W.
*Heaton, W. W.
Heedy, Henry W.
Heffner, Roy W.

*Hegeman, B. A., Jr.
*Heilman, G. H.
*Heineken, Dr.
*Heiser, Victor G.
*Helmel, W. V.
Henry, A. S.
Henshaw, J. O.
Hettiger, E. P.
Hickok, C. N.
*Hicks, Lewis W.
Higgins, Dean
*Higgins, John D.
Higgins, W. B.
*Higinbotham, N. J.
Hildreth, T. F.
*Hilleary, Edward D.
*Hinchman, John J.
Hirschland, F. H.
*Hitchins, C. S.
*Hitchins, R. A.
*Hitz, Charles
Hobart, S. O.
*Hoerle, C. G.
Hoerle, Frank D.
Hoffman, William L.
*Hohl, G. M.
Holliday, Alexander H.
*Holloday, J. A.
Holloway, W. W.
Holmes, C. O.
*Holmes, J. E.
Holzworth, C. R.
*Hoopes, E. S.
Horner, W. S.
Howard, John J.
Howell, Alfred C.
Howell, Herbert P.
Howell, Walter R.
Howland, H. P.
*Howland, R. B.
*Howland, S. W.
Hoyt, Elton, 2d
*Huessener, K.
Hufnagel, F. B.
Hughes, E. E.
*Hughes, E. P.
*Hughes, G. T.
Hughes, H. L.
Hughes, I. Lamont
Hughes, John
Hughes, William H.
*Hulgrave, D. F.
Hulick, William H.
*Hulick, William H., Jr.
Hume, J. E. N.
*Humphrey, G. M.
*Humpton, C. F.
*Humpton, W. G.
*Hunter, Gale
Hurd, H. M.
Hurlburt, William G.
Huston, A. F.
Huston, Frank R.
*Huston, Norman
*Hutchinson, George
*Hyman, Joseph

*Igoe, Andrew J.
*Igoe, James J.
Igoe, Peter
*Inscho, J. J.
*Ireland, J. Morris
Irvin, W. A.
Isham, Phillips
Ives, Edward L.
Ives, L. E.

*Jackson, V. P.
Jameson, A. H.
*Jamison, C. F.
*Jefferson, W. H.
*Jenkins, John
*Jenks, Raymond D.
*Jennings, J. E.
*Jennings, W. H.
*Jenson, K. R.
*Johnson, B. W.
Johnson, M. E.
Johnson, Percival
*Johnson, T. M.
Johnston, C. T.
*Johnston, E. M.
*Johnston, E. N.
Jones, B. F., 3rd
*Jones, Floyd
*Jones, Frank H.
*Jones, Frank W.
Jones, H. L.
Jones, I. O.
*Jones, J.
Jones, J. D.
Jones, J. M.
*Jones, John Price
Jones, L. J.
Jones, Wm. Larimer, Jr.
Jones, William S.
*Jordan, F. S.
*Joys, Carl C., Jr.

*Karcher, K. M.
*Kauffman, E. J.
Kebler, E. A.
Keefe, D. C.
Keeney, R. M.
*Kelley, C. L.
*Kelley, R. B.
Kelly, M. B.
*Kelly, N. A.
Kennedy, James B.
*Kenyon, A. A.
Ker, Severn P.
Kerchner, L. S.
Kerr, D. G.
*Keyes, R. W.
*Kidd, W. S.
*Kiley, LeRoy D.
*Kiley, Thomas W.
Kilgore, R. M.
Kimball, G. C.
*Kimball, W. A.
*King, Charles P.
King, Paul M.
King, Willis L.
Kinsel, T. F.
Kirby, William J.
*Kirkbride, Franklin B.
*Kirkpatrick, H. B.
Kittredge, J. P.
Klauer, William H.
*Klein, L. C.
*Kline, C. T.
*Knight, R. W.
Knisely, Edward S.
Konkle, Creighton M.
*Koon, Sidney G.
Korndorff, L. H.
*Kraeling, Harry A.
Kranz, W. G.
*Krebs, F.
*Kreutzberg, E. C.
*Krieg, Charles
*Kruse, R. H.
*Kuhn, W. R.
Kuker, S.
*Kulas, E. J.

Lackner, R. A.
*Lamm, Olof H.
Lamont, R. P.
Lanahan, Frank J.
Lanahan, J. S.
*Landay, M. N.
*Landon, H. H.
*Langdon, Amon W.
*Langdon, W. G.
Langenbach, Edw.
*Langford, Mr.
*Lapham, E. B.
*Lark, Charles T.
Larkin, J. K.
*Laterman, Edward
Latta, W. L.
*Laub, G. A.
Laughlin, Geo. M., Jr.
Laughlin, Ledlie I.
*Lauterstein, Ben.
Lavine, Saul
Lawson, William B.
Lea, Robert C.
*Lea, Rowland E.
*Lear, O. L.
Leavitt, A. T.
LeBarre, R. S.

*LeBoutillier, George
*Lee, Albert G.
*Lee, H.
Lee, Ivy L.
Lee, P. Blair
Leech, Malcolm W.
Leet, George K.
*Lejuste, C. M.
Lewis, H. E.
Lewis, John F.
*Lewis, Richmond
*Liebawitz, S.
*Liggett, Sidney S.
Linney, J. R.
*Linsley, J. L.
Lippincott, James
*Lippincott, R. H., Jr.
Lissberger, B.
Littler, Carl W.
*Llewellyn, Geo.
Llewellyn, Paul
Locke, Wilbur S.
*Lockwood, Arthur J
*Loengard, R. O.
*Long, W. L.
Longacre, John
*Loomis, E. W.
Loomis, F. H.
*Loud, H. S.
*Loughman, E. D.
Lovejoy, Frederick B.
*Lowe, L. J.
*Lowenstein, A. L.
Loxley, Charles E.
*Ludlam, Frank
Lundie, John
Lustenberger, L. C.
*Lyne, Lew F.
*Lynch, E. C.
*Lynch, Warren J.

MacCleary, W. M.
*MacCormack, Clyde
*MacDonald, A. E.
MacDonald, R. A.
*Macintosh, H.
*MacKinnon, Donald
McAlarney, J. H.
McBride, William
McCauley, J. E.
McCausland, W. C.
*McClain, J. B.
*McClelland, E. H.
*McClintic, H. H.
*McCormack, A. M.
McCormick, S. L.
*McCune, Rowe
McDonald, Joseph A.
McDonald, Thomas
*McElroy, S. A.
McElwain, John
McFarland, A. J.
McFate, W. M.
McGee, Harry L.
McGonagle, Wm. A.
*McGraw, T. H.
McGraw, T. H., Jr.
*McGregor, H. B.
McIlravy, W. N.
*McIlvain, J. G.
*McIntyre, W. W.
McKaig, W. Wallace
*McKay, William E.
McKelvey, E. N.
McKelvy, E. A.
McKenna, Roy C.
McKesson, J. S.
McKinney, R. Grant
*McKinnon, J. H.
McKnight, Charles, Jr.
McLauchlan, J. C.
*McMillan, W. W.
McMillen, A. K.
*McNally, E. J.
*McNamara, J. F.
*McNaughton, James
*McNulty, James C.
McQueen, J. W.
Mace, A. W.
Mackall, Paul
Maguire, W. G.
*Mahl, F. W.
*Mahon, R. V.
*Main, Fred L.
*Main, J. H.
*Maloney, J. E.
Mann, Albert C.
*Mann, R. V.
*Manson, F. M.
Manville, Tracy F.
Marble, A. B.
*Markey, John J.
Marquard, F. F.
Marsh, K. H.
Marshall, C. D.
*Marshall, E. E.
*Marshall, P. M.
Marshall, R. M.
*Martens, Paul
*Marvin, Fred R.
*Massey, R. H.
Mather, Samuel
Mathesius, W.
Mathews, J. A.
*Mathewson, N. H.
*Maxwell, Brace
*Maxwell, Joseph S.
*Maxwell, Maxwell C.
*May, H. A.
May, Herbert A.
*May, John
*Mayer, Oscar N.
*Mays, S. W.
*Meade, Charles A.
*Meanly, M. B.
Meissner, C. A.
*Meissner, H. G.
*Menzies, R. J.
*Merica, Paul D.
*Merkt, G. A.
*Merrill, H. G.
Merriman, D. A.
Meskimen, H. D.
Meyer, Arthur L.
*Meyer, A. P.
*Meyer, George L., Jr.
Meyers, F.
*Meyers, George F.
Michaels, Joseph
*Miller, C. R., Jr.
*Miller, F. B.
*Miller, F. W.
Miller, Harry J.
*Miller, J. A., Jr.
*Miller, James R.
Miller, Louis H.
*Miller, Robert
Miller, W. A.
*Miller, W. W.
Millhouse, William E.
Milliken, F. C.
*Mills, E. D.
Mills, Edwin S.
Mills, James R.
*Minich, Russell A.
*Minuse, A. W.
*Mitchell, George B.
*Mitchell, Harbour
*Moechel, Louis
Moffat, A. Q.
*Moffat, Benjamin
Moffett, C. A.
Mogan, C. J.
*Mohr, G. K.
*Monahan, C. J.
*Monks, J. J.
Montgomery, J. E.
Montgomery, T. D.
*Moody, D. L.
Moore, G. W.
Moore, H. G.
Moore, Philip W.
*Moore, William M.
*Moran, E. F.
*Moran, Joseph H.
Moreland, W. C.
Morris, A. F.
Morris, W. J.
Morris, William J.
*Morris, W. W.
*Morrison, J. H.
Morrow, Hugh
*Morse, Earle

*Morse, Perley
*Morss, D. M.
*Mowry, James G.
*Moxham, Egbert
*Moyer, L. M.
Mozier, M. L.
Mueller, O.
*Mueller, O. B.
*Mulhall, Walter
*Mundle, A. C.
*Mundy, R. F.
Murray, J. B.
*Murray, L. Weimer
*Murray, Thomas E.
*Murray, Thomas E., Jr.
*Myers, H. C.

*Nason, Albert J.
Naugle, H. M.
*Nelles, Claude
*Nessle, J. B.
Newman, R. K.
Newton, H. B.
Newton, John B.
Nicholas, Richmond
Nichols, W. W.
*Nicholson, C. B.
*Nicoll, J. C., Jr.
Nieman, C. J.
Niemann, C. F.
*Norris, Alfred E.
*Norris, Frank P.
Norris, George L.
*Norton, Chester D.
*Norton, R. H.

O'Bleness, H. M.
*O'Brien, H. G.
O'Brien, P. W.
*O'Neil, F. N.
O'Shea, B.
O'Toole, Edward
*O'Toole, William
*Oberhauser, T. W.
Ogden, F. A.
*Ogden, L. E.
*Ohl, R. B.
*Ohnell, Ernst
Oliver, W. H.
Orrok, George A.
*Ong, Edwin M.
*Overton, C. I.

*Page, Rufus W.
Palmer, William P.
Pardee, H. A.
Pargny, E. W.
*Park, Earl S.
Park, Laird U.
*Parker, E. J.
Parker, Edward L.
*Parker, J. A.
*Parsons, William
*Patterson, John W.
*Patterson, S. B.
*Pauley, James B.
Pauly, K. A.
*Payne, L. N.
Pease, B. S.
*Pease, M. H.
Peck, C. J.
Peffer, G. W.
Pendelton, John S.
Pennock, C. A.
Perin, Charles P.
Perkins, H. F.
*Perkins, W. H.
*Perkins, W. T.
Perley, W. B.
Perry, J. E.
*Perry, W. A.
Peters, Richard, Jr.
*Peterson, W. H.
Petinot, N.
Pettis, Clifton D.
*Pettis, William M.
Pfeiff, L.
*Phillips, F. Rees
*Phillips, W. L.
Phillips, W. Vernon
Phillipson, B. F.
Pierce, Clifford E.
Pilling, W. S.
*Plant, W. J.
Pleasance, H. H.
*Plumb, C. W.
*Plummer, James
*Pointer, Sir Hugh
*Porter, Ralph W.
Pouch, W. H.
*Poucher, R. I.
Pratt, R. H.
*Prenosil, S. W.
*Prescott, W. B.
*Preston, A. H.
*Priestley, W. J.
Prosser, T. D.
*Pueyrredon, Honorio
*Pumphrey, E. D.
*Pumphrey, M. E.

Quarrie, B. D.
*Quennerstedt, Thorsten
Quinn, Clement K.

*Raleigh, C. J.
Ramage, William Haig
Ramsburg, C. J.
Rawstorne, C. D.
Raymond, H. A.
*Read, T. T.
*Reason, E. L.
*Rebeske, E. C.
Reed, Walter S.
Reeves, Samuel J.
*Reeves, Wm. H., Jr.
*Rehnberg, K. P.
Reid, John
Reilly, Edgar J.
*Remington, Franklin
Renshaw, Edwin J.
Reynders, J. V. W.
Rhodes, C. H.
*Rice, N. M.
*Richardson, H. C.
*Roach, W. O.
Roberts, J. H.
*Robertson, L. B.
Robertson, W. F.
*Robinson, Lucius W., Jr.
Robinson, T. W.
*Rochester, R. K.
Rockwell, L. D.
*Rodgers, F. L.
*Rodman, C. W.
Roesch, J. A.
Rogers, William A.
*Romney, Leo
Rose, George E.
*Roser, C. G.
*Rowe, W. L.
*Rukeyser, M. S.
*Russell, A. G.
Rust, E. G.
Rust, H. B.
Rust, R. R.
Rust, W. F.
*Rutherford, W. S.
*Ruzicka, Charles

St. Clair, Frank G.
Sargent, G. W.
Sarratt, J. T.
Satterthwaite, George
Savage, Joseph F.
Sawhill, E. P.
*Saxman, M. W.
Schaefer, Philip
*Schaffer, A.
Schiller, William B.
*Scholl, Joseph
Schleiter, W. F.
*Schrage, W. C.
*Schroeder, R. C.
Schwarzenberg, E. A.
Scofield, C. E.
Scott, W. W., Jr.
*Seeton, George W.
*Seicht, E. R.
*Shanklin, Dr. R. V.
Shants, G. T.
*Shaw, George E.
*Shea, P. C.

*Shearer, R. B.
Sheldon, E. W.
Sheldon, Harry E.
Sheldon, Samuel B.
*Sherman, James A.
Shick, F. A.
Shimer, W. R.
Shoffstall, A. S.
Sias, J. M.
*Sicard, H. C.
Sigafoos, M. H.
*Simmons, C. F.
Sinclair, Duncan G.
*Singleton, A.
Sites, F. R.
*Skuse, T. J.
Sloan, Burrows
*Sloane, Parker
Slocum, Frank S.
*Sloppenbach, F. E.
Smart, George
Smiley, John B.
Smith, Austin D.
*Smith, A. E.
*Smith, David H.
*Smith, Dudley J.
*Smith, F. G.
Smith, Floyd K.
*Smith, George
Smith, H. Sanborn
*Smith, William
*Smyth, W. B.
*Snow, E. L.
Snyder, H. S.
*Solomon, H. Alfred
Solomon, Max
Somers, Joseph T.
Sommer, B. L.
Spackman, G. D.
Spain, Batt L.
*Sparfeld, E. H.
Sparhawk, Edward M.
*Spear, C. M.
*Speidell, J. W.
*Spillane, Richard
Spilsbury, H. G.
*Spooner, A. P.
*Sprague, F. K.
*Sproul, J. R.
Sproull, E. T.
Stafford, Samuel G.
Stambaugh, H. J., Jr.
Stanley, Robert C.
*Starr, G. W.
Stebbins, H. S.
Steel, Charles C.
Steif, Erwin A.
*Stephens, Mr.
*Stetson, Eugene W.
*Stetson, Henry T.
Stevens, Charles G.
Stevenson, A. A.
Stevenson, M. R.
Stewart, Hamilton
*Stewart, W. H.
*Stoll, H. E.
Stoltz, G. E.
*Stone, F. L.
*Stone, H. L.
Stoop, W. J.
*Stover, Holly
Stratton, W. H.
*Straub, Archer J.
Straus, H. H.
Strong, James B.
*Sturtevant, Paul
Sullivan, G. M.
Sullivan, George R.
Sullivan, W. J.
*Sully, R. A.
Summers, Harry W.
*Summers, J. Mills
*Sumner, Eliot
Sussman, Julius L.
Swank, Ralph L.
Swartz, Alfred H.
Swindell, E. H.

*Talbot, C. G.
*Taylor, Allen
Taylor, Arthur W.
Taylor, Clifton
*Taylor, C. D.
*Taylor, F. G.
*Taylor, William N.
Tencher, R.
Thomas, A. J.
*Thomas, C. E.
*Thomas, E. B.
Thomas, E. P.
Thomas, George, 3rd.
Thomas, G. T.
*Thomas, W. D.
Thompson, David P.
Thompson, E. D.
*Thompson, John F.
*Thompson, J. I.
Thorp, G. G.
Tickner, Frank W.
Tiemann, Hugh P.
*Tlach, V. F. J.
Tobias, Wm. M.
Todd, William B.
*Tower, Louis
*Tower, William
Towne, Thomas
Townsend, A. J.
Townsend, H. E.
*Traer, C. S.
Tredennick, H. L.
*Treharne, E. B.
Trimble, H. N.
*Trude, Walter
*Tschirky, Leopold
*Tucker, J. O.
Tucker, R. S.
*Tulloch, J. R.
Tutein, Dexter A.
Tutein, E. Arthur

Unger, J. S.
Uphouse, Harry G.
*Usher, H. L.
Utley, S. W.

Van Cleve, A. E.
*Vandevort, F. F.
Vant, George H.
Velte, Ralph C.
Vogt, A. W.
Voight, Paul F., Jr.
*Von Frankenberg, H. T.
*Vosburgh, F. J.
Vosmer, William F.
Vought, Charles S.
Vreeland, George W.

Waddell, Jacob D.
Wade, Fred A.
*Wadhams, Albion J.
*Wagner, Ernest J.
*Wagoner, Z. C.
*Wahlberg, Axel F.
Waldo, Fred J.
Wales, S. S.
*Walker, G. B.
*Walker, J. N.
*Wall, George M.
*Wallon, J. G.
*Walsh, C. E.
*Walsh, James L.
*Walsh, Philip C., 3rd.
*Walsh, William J.
Walters, F. W.
Walton, H. G.
*Walton, Thomas M.
Ward, J. H.
Ward, T. C.
Wardwell, A. H.
*Warley, H. W.
*Warren, J. A.
Warren, J. B.
Waterhouse, G. B.
Waters, John H.
*Watson, G. E.
Watson, Ralph H.
Wayland-Smith, R.
Webb, F. J.
*Webber, Fred
Wegener, E. R.
*Wehr, G.
Weir, E. T.
*Weiss, Frank A.

Weiss, Jay G.
*Welsh, Charles F.
Westfall, H. D.
Wetherell, L. H.
*Wetzel, J. E.
*White, C. S.
White, G. A.
*White, H. E.
White, Herbert R.
*White, Hubert A.
*White, R. W.
*White, W. F.
*White, W. Foster
*Whitehead, J. B.
*Whiting, John F.
*Whitney, R. H.
*Wickenden, T. H.
Wickwire, T. H., Jr.
*Wight, S. B.
Wiley, Brent
Wilkinson, H. S.
*Willard, L. L.
*Willcox, R. I.
Wille, Frederick
*Williams, B. P.
Williams, H. D.
Williams, I. B.
Williams, J. C.
*Williams, R. B.
*Willock, S. R.
Wilson, Parker F.
Wilson, Willard
*Wing, W. S.
Winckler, E. E.
*Wonham, F. S.
Wood, F. W.
Wood, Richard G.
Wood, Walter
Woodard, L. A.
Woods, John E.
Woods, Leonard G.
Worth, E. H.
Worth, W. A.
Worton, Samuel G.
*Wotherspoon, W. L.
Wright, J. David
Wright, S. D.
Wright, Wm. H.
Wuthenow, William

Yeates, F. C.
*Yoder, J. O.
*Yohe, C. M.
Younglove, E. H.

*Ziesing, H. H.
*Zimmer, L. M.
Zimmerman, R. E.
*Zook, Joseph

PARTICIPANTS OCTOBER MEETING

(*Guests)

Abbe, Albert N.
*Abbott, R. Boone
Abel, A. E.
*Adams, A.
Adams, E. M.
Adams, F.
*Adams, Homer
*Adams, R. J.
Affleck, B. F.
Ahlbrandt, G. F.
Akin, Thomas R.
*Akin, William M.
Alder, T. P.
*Allderdice, Norman
Allderdice, Taylor
*Allen, A. A.
Allen, H. J.
*Allen, J. E.
Allen, John N.
Allen, W. L.
Alley, James C.
*Alley, William R.
Allyn, A. W.
*Amis, F. W. T.
Anderson, Brooke
*Anderson, G. E.
*Anderson, G. L.
*Anderson, H. A.
Anderson, Nils
Andrews, Jay I.
Armstrong, V. C.
Arnold, L. L.
Arthur, T. A.
*Artman, A. J.
Atwater, C. G.
Austin, W. H. A.

Baackes, Frank
Backert, A. O.
Badlam, Stephen
Baily, R. M.
Baily, T. F.
Baker, Merrill G.
*Baker, P. R.
Bakewell, D. C.
Baldwin, C. Kemble
Baldwin, H. G.
Balkwill, George W.
*Bancker, W. F.
*Bandler, Wm. A.
*Banker, L. G.
Banks, A. F.
Barashick, Aaron
*Bardgett, E. R.
Barnes, Charles A.
*Barnum, J. P.
Barrows, W. A., Jr.
Barrows, W. A., 3rd
Bartlett, Lyman
Batchelor, E. D.
*Bateman, W. H. S.
*Bath, Edward M.
*Baur, Charles S.
*Baxter, H. A.
*Bayley, Guy D.
Beale, H. A., Jr.
*Bean, Henry W.
*Beck, Robert E.
*Becker, F. D.
Becker, Joseph
*Becket, F. M.
*Beegle, C. H.
Beeson, C. E.
*Bell, Ainslee
Bell, C. H.
Bell, G. Graham
Belsterling, C. S.
Benedict, E. L.
Bennett, C. W.
Bennett, D. P.
*Bensel, Arlington
*Bent, Arthur
Bentley, Robert
*Bertin, M. J. A.
*Best, Charles M.
Bever, John J.
Biggert, C. F.
*Bingaman, Ralph W.
*Binnix, F. K.
Birney, E. H.
*Bishop, Joseph E.
*Bissell, F. R.
*Bissell, J. B.
*Black, J. B.
Blackwell, Harry E.
*Blakeley, G. B.
Blakeley, G. H.
Block, L. E.
Block, P. D.
Blowers, William B.
*Bodevin, Henry
*Boeker, O. F. G.
*Bolton, J. C.
*Bolton, Newell
*Bonnell, W. A.
Bonner, James B.
*Bonner, Leonard A.
Booth, C. H.
Booth, Lloyd
Bothwell, Walter J.
Boutwell, R. H.
Boutwell, Roswell M.
*Bower, W. C.
*Bowers, E. C.
*Boyd, C. A.
*Boyd, James
Boynton, A. J.
Bradley, Carl D.
Bradley, C. S.
Bradley, H. S.
*Brady, Frank A.
Brainard, J. W.
*Brandeis, Eugene
*Bransome, E. D.
Brassert, H. A.
*Breed, R. E.
*Breitung, Max
*Bretland, C. W.
*Brex, E. C.
Brion, A. E.
Brion, Lester
*Brisbane, Arthur
*Brodhead, Frank M.
Brokenshire, E. L.
*Brooke, Frank W.
Brooke, George, 3rd
Brooke, Robert E.
Brotherton, F. C.
*Brown, A. J.
*Brown, A. W.
Brown, Fayette
Brown, Frank L.
*Brown, H. B.
*Brown, J. H.
*Brown, P. D.
*Brown, William A.
Browne, de Courcy
*Browning, R. R.
*Brudi, William H.
Brunke, F. C.
Buck, C. A.
Buck, L. J.
*Buckley, William
Budd, R. B.
Buell, James A.
Buffington, E. J.
*Buick, James M.
*Bull, F. C.
*Burnett, L. S.

Burton, Carroll
Butler, E. T.
*Butler, Patrick
*Butler, Smedley D.
Butt, Howard
*Buzell, C. E.

*Calkins, Loring G.
*Callow, W. K.
*Campbell, B.
Campbell, James A.
*Campbell, N. A.
Campbell, Robert D.
*Cannon, Russell A.
Cantley, C. L.
Cantley, Thomas
*Carins, R. A.
Carney, Frank D.
*Carroll, William J.
Carruthers, J. G.
*Carnahan, J. P.
Carse, David B.
*Carse, Donald R.
Carse, Henry R.
Carse, John B.
Carse, John Bradley
Carson, George C., Jr.
Carter, Emmett B.
*Carter, G. O.
Casey, F. Y.
Casey, J. S.
*Casey, John F.
*Casterton, J. W.
Cebrat, Paul
*Cederquist, Milton O.
*Chambers, C. E.
Chamberlain, A. H.
*Chandler, Henry T.
*Chandler, W. A.
Chapin, A. H.
*Chapman, A. M.
*Charles, J. G.
Charls, George H.
Cherry, C. A.
*Childs, G. A.
*Chisholm, C. G.
Christ, E. W.
Christian, A. W.
Clarage, Arthur T.
*Clark, Donald G.
Clark, Edward F.
Clark, F. E.
Clark, J. B.
Clark, R. W.
Clarke, C. E. F.
Clarke, E. A. S.
*Claster, Joel
*Claussen, J. A.
*Clements, B. A.
*Clisby, H. I.
Close, C. L.
Cluff, Charles C.
Clyde, W. G.
*Coburn, F. Ward
*Coleman, C. P.
Colladay, Frank H.
*Colling, A. F.
Collins, C. A.
*Collins, C. I.
Collins, E. C.
*Condit, E. A., Jr.
*Cone, Edwin F.
*Conneely, E. K.
Connell, F.
*Connell, H. R.
Connors, George W.
Cook, Howard H.
Coonley, Howard
Coons, Perry T.
Corbett, W. T.
Corey, A. A., Jr.
Cornelius, Henry R.
*Cotsifas, D. D.
*Cotter, Arundel
*Cotter, W. E.
*Cowdrey, J. E.
Cox, Walter S.
Craig, Sam N.
*Craine, Clyde P.
Crandall, L. E.
Crawford, George G.
*Crawford, H. C.
Crawford, W. D.
*Creveling, G. F.
*Critchett, J. H.
Crosby, Fred B.
*Cross, L. W.
Crotsly, A. W.
*Crowell, E. D.
Crowley, Dennis, Jr.
Cueman, J. Bently
*Curl, Herbert
*Curley, J. F.
*Curtis, F. K.
*Curtiss, L. M.
Cutler, W. C.

Dalton, H. G.
*Dalton, Ralph L.
Damerel, George
*Dana, R. H.
Danforth, A. E.
Darlington, Thomas
*Darragh, C. D.
*Dauler, H. N.
Davey, A. I.
Davey, W. H.
*Davidson, Louis R.
Davies, Albert P.
Davies, George C.
Davis, Edward L.
Davis, G. L. L.
*Davis, H. H.
*Davis, J. A.
*Davis, Walter A.
Davis, W. P.
De Lano, S. P.
Dell, Charles S.
Deming, Fred C.
*Denio, George L.
*Denman, L. E.
*Denneny, George
*Denyven, G. W.
Desmond, John F.
*Desmond, L. E.
Detmers, Arthur C.
Deutsch, Lee
Deutsch, Samuel
Devens, H. F.
Devens, Richard
Dickerson, A. V.
*Dickey, William C.
*Dickinson, H. B.
*Dickson, H. C.
*Dickson, T. W.
Diehl, A. N.
*Dietrich, A. C.
Dietrich, Andrew J.
*Dillon, James J.
*Dirkes, F. A.
Ditto, M. W.
*Doane, George B., Jr.
Dohn, A. F.
*Donaldson, W. E.
Donner, Joseph W.
Donner, Robert
Donner, W. H.
Dorman, A. D.
Dorsey, R. M.
*Doty, John W.
*Dow, James K.
Dowling, Eugene
Downey, J. A.
Duane, James, Jr.
*Duncannon, Emil
*Dunn, S. S.
Dunsford, J. R.

Easton, H. M.
Eaton, W.
*Edgcomb, Harry
*Edgcomb, Leslie
*Edgerley, W. H.
*Edwards, C. S.
*Edwards, D. F.
Edwards, E. T.
Edwards, Gordon L.
Egbert, Justus
*Eller, H. D.
Ellis, J. M.
Emery, R. Edson
Endicott, George
Eppelsheimer, D.

Estep, Frank L.
Exstein, H. L.
Eynon, D. L.

*Fairchild, W. A.
Farkell, George C.
*Farmer, Malcom
Farrell, James A.
Farrell, J. J.
Farrell, R. G.
*Farrell, W. K.
*Fay, C. F.
Fell, Charles
*Ferguson, Everett
*Fessenden, Robert
Field, H. E.
Filbert, W. J.
Finch, J. H.
Fink, George R.
Fisher, Charles A.
Fisher, F. A.
Fisher, P. L.
*Flannery, Walter R.
Fletcher, John F.
Floersheim, Bert
Flora, A. N.
Follansbee, W. U.
*Follmer, A. A.
*Forbes, Alvin
Forbes, W. A.
Forster, C. H.
*Forster, W. C.
*Foster, Charles G.
*Foster, D. G.
*Foster, H. M.
*Foster, R. L.
Foster, T. J.
*Fox, A. W.
*Fox, Gordon
*Fox, Walter
*France, E. A.
Francis, Lewis W.
Fraser, J. S.
*Freeman, P. J.
*French, James
Freyn, H. J.
*Froggett, J. F.
Froment, E. McK.
Frost, Frank R.
Fry, Lawford H.
*Fuchs, G. George
Fuller, Frank D.
Fuller, Frederick A.
Fuller, H. Harrison
*Fuller, T. S.

*Gadd, L. L.
Gaffney, A. T.
*Gaffney, E. P.
*Gage, C. W.
Galbraith, A. T.
*Gallagher, J. W.
*Galloway, C. W.
Gardner, K. C.
Gardner, Wm.
*Garihan, Edward L.
*Garrett, H. S.
Garrity, John E.
Gary, E. H.
Gaskill, J. W.
*Gastmeyer, R. W.
*Gaul, C. W.
Gault, J. W.
Geissmann, Theodore
Gellert, N. H.
Gerry, Roland
Gewecke, J. H.
Gibbs, E. Everett
*Gibson, G. R.
*Gibson, R. W.
Gillespie, C. L.
Gillespie, J. M.
*Gilligan, Richard
*Gillispie, Larry
Gillispie, Robert W.
*Gilpin, G. G.
Glasgow, W. H.
Glass, Andrew
Gleason, W. P.
*Goedecke, Milton
*Goldsmith, B. J.
*Gomber, W. J.
Gordon, F. H.
*Gosselin, L. C.
Grace, E. G.
Graham, C. J.
*Graham, W. H.
Granger, L. D.
*Gray, J. J.
Grayson, S. A.
Green, W. McK.
Greenawalt, John E.
*Greenberg, Samuel
*Greene, Edgar T.
*Greene, George F.
*Gregg, Cecil D.
Gresham, W. B.
*Griffin, H. L.
Griffin, J. B.
*Griffith, E. M.
*Griffiths, E. A.
Grose, James H.
*Gross, J. G.
Gross, John M.
*Grove, Clark
Grugan, Justice F.
*Grundy, George H.
Guba, Philip M.
*Guest, G. C.
*Guttzeit, Charles W.

Hackett, S. E.
*Hager, T. W.
*Haggerson, F. H.
Haggerty, Frank L.
Hall, R. S.
*Hall, T. H., Jr.
Halstead, Kenneth B.
*Ham, Thomas C.
*Hamilton, A. S.
Hamilton, H. V.
*Hamilton, Robert E.
*Hamilton, W. J.
Hammond, James H.
*Hammond, John H.
*Hammond, J. S.
Hancock, W. W.
Hanna, W. J.
*Hanson, Walter W.
Harding, Harvey
*Hardy, C. K., Jr.
*Haring, C. E.
Haring, W. S.
Harper, A. M.
*Harper, Harry
*Harrington, H. C.
*Harris, E. H.
*Harris, T. A.
*Harris, W. J.
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